THE

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THE SOUTHWARK BRIDGE EXPLOSION.

MAJOR CARDEW is to be congratulated on the despatch which he exercised in the matter of the Southwark Bridge explosion. The unfortunate occurrence took place on February 1st, the Board of Trade inquiry was held on the 4th, and Major Cardew's exhaustive report on the subject is dated the 7th of the same month.

The great urgency, however, displayed by the Board of Trade Inspector, seems to have been to some extent nullified by the Board itself, for, to the best of our knowledge, the report was not in the hands of the public before March 25th. We have not the slightest doubt that the company most concerned in the matter had the recommendations of the Inspector put before them long before the report was issued, but considering the widespread interest—we had almost said anxiety—at the present moment, we do think a little more precipitancy on the part of the Board of Trade was necessary. This feeling is deepened when we consider the great importance of some of the remarks contained in the report. We have no desire to register a hasty complaint, and it may be that matters beyond our knowledge have prevented an earlier issue; but as we have already indicated, the most urgent and the most pressing problem before electrical engineers is that of preventing absolutely the repetition of the recent lamentable accidents, and we feel that under the circumstances the Board of Trade ought, in the matter of explosions, to move with the greatest expedition. There can be little doubt that the Southwark Bridge explosions accentuated the difficulties surrounding the question. From the report of the rather complicated arrangement of culverts and pipes on Southwark Bridge, we gather that at the south end a brickwork culvert, used for the surface drainage, crosses under the roadway; into this culvert roadway catch-pits discharge. Under the footway on the west side there is a manhole closed by a stone slab, and giving access to the culvert; 3 inches above the culvert a 3-inch cast-iron gas pipe passes, from which is led a small service pipe. The pipes belonging to the electric lighting company cross over the culvert and over the 3-inch gas pipe, but under the small gas service pipe. None of the electric lighting company's pipes, however, at this spot contain mains; on the east side of the bridge there are a large number of electric mains in iron pipes and in bitumen casing passing under the footway and over the culvert.

It seems to have been clearly established at the inquiry that the first explosion occurred in the culvert under the pavement and roadway on the west side of the bridge, where, as has been stated, no electric mains existed; this explosion was followed by three others in the street boxes of the electric lighting company on the east side of the bridge. It was found on opening the ground over the drainage culvert that a large crack existed in the 3-inch gas main, out of which

the gas was coming in volumes, and found an easy access to the culvert. According to Major Cardew, the explosion appears to have traversed the culvert and followed the course of the gas which had percolated into the electric light street boxes on the east side.

We may derive a crumb of comfort from the fact that, despite the difficulty of exactly ascertaining how the gas was fired, the electric lighting mains are clearly exonerated from any participation in the explosion. Apart from the fact that there were no electric mains in the near neighbourhood of the first explosion, the central station voltmeter recorded no trace of disturbance, and Major Cardew distinctly states that as the mains in use were concentric cables properly earthed, it is not likely that they produced a spark. It may have been a lighted match thrown into the catchpit, or it may have been a spark struck by a horse's foot, or a wheel passing near the gully grating out of which gas was issuing; it was not caused electrically, and therefore it ceases to be of vital interest to us. But though the electric lighting company did not manufacture the spark which caused the mischief, they are saddled with the responsibility of allowing the explosion to travel along their pipes. The most striking features about the Southwark Bridge accident, according to Major Cardew, are: "The distance to which it appears that a series of explosions may travel along the electric mains which form a gigantic network under the whole of the streets of the City, and the proof it affords of the insufficiency of any ordinary system of ventilation of these pipes and street boxes, if gas can find an easy access to them, and the necessity of exercising great care to make and keep the street boxes impervious to gas." It is of the highest importance that the conduits and pipes of an electrical system should be kept free from gas; but it seems to us that the difficulties of doing so are comparable with those of the gas company in keeping gas in the pipes. If, however, these difficulties are unsurmountable, and if the ordinary means of ventilation fail, as in the opinion of Major Cardew they do, we appear to be driven towards some solid system. It is clear that by the adoption of such systems we should loose many of the advantages which conduits provide. Nor is it to be overlooked that there are some systems of conduits which have been presumably kept free from gas, or, at any rate, which have experienced an immunity from explosions. The safety of the public is, however, the first desideratum, and it is to the ultimate advantage of the industry that the possibility of accidents should be provided for. There are many engineers who claim that they can keep the mains entirely free from gas by using cast-iron boxes, but we are afraid that such a leak as the one experienced on Southwark Bridge would sorely test the integrity of any system.

Granting that the gas companies have been primarily responsible for many of the explosions, is it possible to make gas pipe joints so perfect that the contingency of a cracked pipe is not likely to arise? In the light of the Southwark Bridge explosion, gas must be kept out of the pipes and conduits of an electrical system at all costs; and if ordinary means of ventilation fail to clear them of an extraordinary inrush of gas, are we really left with much choice in the selection of a perfectly safe method of laying mains? Does it not come to this, that culverts will have to be abandoned, and the mains embedded in such a manner so that no space shall surround them for the accumulation of explosive mixtures?

Argon.

It would be interesting to learn in the face of recent developments what the whole of our estimable contemporaries have to say on the question of argon. Can they any longer doubt its close analogy to nitrogen now that it is proved it forms alkaline compounds? No substance but nitrogen, or members of the same family, form alkaline or basic bodies when combined with hydrogen or compound radicals, which latter are again made up of carbon and hydrogen. The alkaline product of Berthelot is either an analogous body to ammonia or an equivalent compound, ammonia containing, therefore, organic radicals. It is possible that the basic product may yield nitrogen on decomposition and not argon; in that case argon would be an allotropic nitrogen, as we suggested at the time of the B.A. meeting of last year, and as Berthelot points out. In any case the views of Rayleigh and Ramsay that the atomic weight is 40 instead of 20 or 21 will not do. It is amusing to read *Nature* of last week, and to note that Ramsay, in a letter, protests that argon has nothing in common with nitrogen. Further, we believe Ramsay had a paper given by his assistants at the Royal Society last week, evidently intended to show that argon does not enter into organic combination. The galling thing is that the combined labours for eight or nine months of a physicist and a chemist could not bring about any combination; whereas, Berthelot, with a very small quantity of material, settled the matter in the first experiment he made.

A Theory of Electrolysis.

In the introduction to his work on electro-chemistry, Ostwald remarks, that to a philosophic mind nothing is more fruitful than the historical study of a science. This statement is strikingly true of the science of electrolysis, to whose development Ostwald has contributed so much. Bucherer has recently engaged his attention upon this, and has emphasised the fact that of all conceptions that of the first and second laws of thermo-dynamics have done most in clarifying our views and in paving the way for new discoveries. For all that, however, the old preconceived notions still exercise their vicious influence. Bucherer has endeavoured to formulate a new theory which shall be innocent of the inconsistencies which surround and poison the generally accepted views. He expounds this theory in the *Electrical World* (N.Y.), Vol. xxv., No. 5, p. 138. The basis is the mass law which in the thermodynamic treatment of chemical reactions has played so important a part. From the standpoint of the mass law, chemical equilibria are viewed as dynamical equilibria. It is difficult to give a notion of this new theory in so limited a space as that of a leaderette, and especially so as Bucherer's exposition of it literally teems with equations. It may be observed, however, that Bucherer regards the potential difference between a metal and its solution as directly due to the relation of the partial pressure of the metallic vapour with which it participates in the equilibrium and the sublimation pressure of the immersed metal. This does not accord with the modern view of electrolysis as represented by Nernst's theory of a solution tension. Bucherer has obviously followed the reasoning used by Ostwald, the difference is that he deals with the partial pressures of the metallic vapour and the molecular non-metallic constituents of a solution, where Ostwald and Nernst consider the osmotic pressures. Oddly enough, however, Bucherer's theory leads to much the same results as the generally accepted theory in spite of the fact that according to one of them the number of ions increases by dilution and to the other it decreases. Bucherer will be certain to attract much attention by his new theory: it is another matter whether it will stand searching criticism.

NOTES ON THE ELECTROSTATIC AND MAGNETIC CIRCUIT ANALOGY.

By J. E. TAYLOR.

At the present time, when both magnetic and electrostatic phenomena are beginning to be more generally regarded from the "lines of force" point of view, the following notes may be of interest. They are mainly derived from a paper read by the writer some time ago.

As in electrostatics, the student who has obtained his knowledge of magnetism from the standard text-books on the subject, will probably have to unlearn much that he has been taught, and, at any rate, cannot fail to derive advantage by regarding the subject from quite another point of view.

In studying magnetic circuits and magnetic actions from the lines of force, or, rather, tubes of force point of view, perhaps the most important step to take is to recognise that in some ways the iron or steel part of the magnetic system of a magnet is of quite subsidiary importance. It is the magnetised air in the air gap or gaps that is effective. Indeed, this should be a very simple deduction from the law of the conservation of energy, for the energy required to produce a given flux of induction through a given magnetic circuit is almost wholly expended in magnetising the air gap, and the air gap is, therefore, the seat of the major portion of the magnetic energy of that system. It is the magnetised air about the poles of a permanent magnet which draws up the soft iron keeper, not the steel. If there be no air gap in the circuit, as in the case of a closed iron ring, then it requires but a feeble magnetising force to produce the induction, little energy is imparted to it and little can be taken from it—that is, it can do little work. Make a small air gap, however, and, generally speaking, the amount of energy required to be supplied by the exciting coil or other means, in order to produce the same flux of induction, is enormously increased. Obviously, it is the air gap on which this extra work is done, and it should therefore be plain that the air is the seat of magnetic energy. In a permanent magnet the function of the steel is to sustain by its coercive force the magnetic field in the air; to resist its tendency to resume the normal unmagnetised state. In fact, the steel plays exactly the same part in sustaining the magnetic system as do the piers of a bridge in resisting the force of gravity by virtue of their rigidity; and it is plain to be seen that the upper and weighty part of the bridge is the principal seat of energy. By providing a short circuit for the lines of force, from pole to pole, in the shape of a soft iron keeper, we can demagnetise the air at will, all the energy previously contained in the air gap being accountable for, either as producing motion or eddy currents in the iron or other metallic masses. Similarly, by forcibly detaching the armature, we remagnetise the air, supplying the requisite energy by the drawing away of the keeper. In drawing away the armature or keeper, therefore, we may say that we supply energy by forcibly elongating or drawing out the tubes of force just as in electrostatics we can draw out the lines of strain between two bodies.* We supply energy by the *extension* of the lines in either case, not by generating more of them, for the number or flux is not altered by these processes. The force of the attraction of the armature when in any position measures the rate at which energy is being supplied to the field at the instant the moving armature passes this position, when the rate of motion is uniform and constant. Consequently, when the armature is close up to the poles, more energy is supplied to the field for a given increase in the gap than when further off, for we know by experience that the force of attraction is much stronger in the former case. The force with which the keeper is attracted being proportional to the number of lines passing through it from the magnet, multiplied by their density, it follows that fewer lines reach it when the gap is enlarged; the diminished rate of energy supply is therefore due to the fact that fewer lines are being elongated.

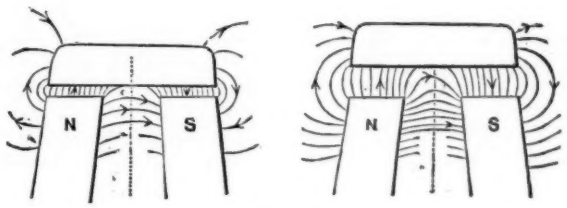
The number of lines of force or induction in a magnetic circuit is measured by the amount of magnetisation; and the width of space allotted to each line or tube by the intensity of magnetisation of the matter in its path. The amount of energy associated with a tube of force is proportional to the length, inversely proportional to the sectional area, and inversely proportional to the permeability of the medium through which it passes. That is,

$$\text{Energy} = \frac{l}{a\,\mu} \times \text{const.}$$

l being the length, a the sectional area, and μ the permeability. When, therefore, the keeper of a permanent magnet is forcibly drawn away, energy is supplied to form the magnetic field, by lengthening the tubes of force. When the tubes are short their average sectional areas are not altered appreciably by a small amount of lengthening, but as the armature recedes, the effect is to increase a almost as rapidly as l in those tubes which still suffer elongation, when the gap is great, and thus little energy is then supplied. This is owing to the spreading out of the tubes of force, and a slight acquaintance with the redistribution which takes place in drawing away the armature of a permanent magnet will, on consideration, show that it is the effect upon the ratio, $\frac{l}{a}$, which measures the supply of energy to the field. When the tubes become much curved and divergent, the section, a, of any tube is one particular section which may be designated the "average" sectional area, it being such that $\frac{l}{a}$ is constant for all tubes having both their sources near one another. By taking the tube small enough, l has only one value for each tube. By "sources" is meant where they emerge from or enter the steel or iron. In fact, taking tubes whose sources are sufficiently near one another, or in other words, between whose ends the magnetic potential differences are the same, since $\frac{l}{a}$ is the energy of a tube, these tubes of force can be regarded as mapping out the magnetic energy of the air, or other medium, whilst at the same time indicating the direction of the force.

It will thus be seen that there is a great amount of similarity between electrostatic lines of strain and magnetic lines of force. The way in which magnetic lines distribute themselves over the surface of the iron or steel is also determined by the same laws, as in electrostatics. That is, the density of the lines depends on the radius of curvature (greater radius, less density), but the action of the laws is limited by the limited permeability of the iron, which prevents many lines emerging from the same spot on the surface of the magnet. For the same reason we do not find all lines emerging normal to the surface, which in electrostatics is invariably the case.

In the case of a permanent horse-shoe magnet, as in fig. 1,



A Fig. 1. B

if we do not go far from its ends, the magnetic difference of potentials between the ends of tubes where they emerge from the N pole to where they enter the S, is the same for all tubes. In either case A or case B, therefore, the ratio, $\frac{l}{a}$, is the same for all tubes traversing the same air gap, or at any rate they tend to equality in this respect, for we must remember that they are not so free to adjust themselves as is the case in electrostatics. Those tubes running direct from N to S have of course double the ratio of those from N to keeper or keeper to S, having double the difference of potentials. In case B, where the gaps have been increased by drawing away the keeper, we see that the ratio, $\frac{l}{a}$, has increased for each

* Electrical Review, Vol. xxxi., p. 427.

tube, assuming, as would be the case, that the number of lines acting has not appreciably diminished, they having only undergone a redistribution, so that whilst some have had their l increased others have had their a diminished, keeping the ratio $\frac{l}{a}$ the same for all as already explained. For instance, those tubes from N to keeper or keeper to S have had their l increased, a not being very much affected, whilst those running direct between N and S have had their a decreased, l being unaffected. A little consideration of this case will show that the redistribution and the variation of $\frac{l}{a}$ taken as indicating the amount of magnetic energy in the air, are consistent with the indications afforded by the force of the attraction of the armature or keeper (against which force the work stored up in the field is done), of the supply of this energy.

Just as in electrostatics we increase the $\frac{l}{a}$ of two similar fields by superposing them against their pseudo-repulsive forces and thus decreasing a, so in magnetism when we bring two similar poles into one another's neighbourhood we increase $\frac{l}{a}$ in exactly the same manner. The distribution of lines of force is in all cases as similar to the distribution of lines of strain as the limited permeability of the iron or steel will allow.

Self-demagnetising Force.—Like a spring in a state of tension, magnetised air tends to resume its normal unmagnetised state. This tendency is called the self-demagnetising force of a magnet or magnetic circuit. The self-demagnetising force of a closed iron ring magnetised circularly is very feeble, as also is that of a long thin bar of iron or steel, whereas it is very strong in a short thick bar, or fairly strong in an ordinary horse-shoe magnet with the keeper removed. With the keeper on the magnet, but for the magnetic resistance of the joint, we have practically a magnetised ring, and therefore very little self-demagnetising force. The greater the air gap of the horse-shoe magnet, the greater this force, which is in reality proportional to the magnetic energy of the system. Taking the energy in the iron or steel as being negligible, the self-demagnetising force is proportional in all cases to the maximum $\frac{l}{a}$. This being so, shows us at once how this force varies with the position of the keeper in a horse-shoe magnet, or with the size and area of the pole pieces in any magnet. It also shows us why a long thin bar should have so much less than a short thick one, although at first glance this is not so palpable as in the preceding cases. It is usually carefully explained that in a long thin bar the polarity being far removed from the centre, it can exert but little demagnetising force on the iron. Apply this theory, however, to the hypothetical case of two similar bars with equal fluxes of induction through them, and alike in all respects excepting that we assume one (fig. 2, case A) to have

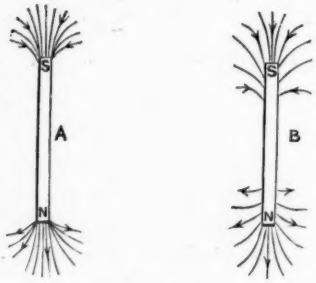


Fig. 2.

its lines of force concentrated entirely on the ends of the bar, so that the polarity is as far removed as possible from the centre, whereas in the other case the lines are spread over a much larger surface of iron.

Now, according to the usual theory, A should have a smaller self-demagnetising force than B, because its resultant polarity is further removed from the centre; but any practical person would perceive in an instant that if it were possible to magnetise a bar as shown at A, the force in B would be much less than in A, in spite of the distance from the centre, of the polarity developed. Now the air gap in A, is of high magnetic resistance, whilst that of B is comparatively low; and the high resistance is a consequence of the limited area of iron surface from which the lines emerge. To grasp this clearly it may be as well to take the analogy of lines of conduction in fluids; given two small conducting spheres immersed in a conducting liquid. Between these spheres a current passes, the leads to them being supposed to be insulated. The lines of current flow or conduction are distributed the same as would be the lines of strain, were the spheres charged oppositely and equally, and insulated in a non-conducting dielectric.* If the distance between the spheres is not great compared with their diameters, then the resistance of the liquid between them increases as they are separated, in the same proportion as the $\frac{l}{a}$ increases. When the distance becomes great, $\frac{l}{a}$ is not appreciably affected by any increases of this distance, as a is increased at about the same rate as l. So with the electrical resistance, which does not increase appreciably with any amount of increase of distance when that distance is great. But we can decrease the resistance when they are apart by enlarging the spheres, and this to any extent we may choose, such enlargement causing a to be increased. In the same way the resistance of the air gap in a long iron or steel bar is small, owing to the fact that the area of the surface from which the lines emerge is great, and can, of course, be made as great as we please by sufficiently lengthening the bar, whilst at the same time the greater length of air gap does not increase this resistance. In this way, then, a feasible explanation of the small self-demagnetising force of long bars appears to offer itself. It is well known that a permanent magnet, made of a short thick steel bar, cannot be so readily nor so highly magnetised as a long bar or a horse-shoe magnet, and that it will not retain its magnetisation so long. This is on account of the great self-demagnetising force which exists in a short bar. With equal fluxes of induction per unit area of section, each tube of force as it emerges from the steel is much more squeezed up, as it were, in the case of a short thick bar than in a thin one of the same length; and, in fact, here again the maximum, $\frac{l}{a}$, of the tubes of force determines in each case the self-demagnetising force of the system. Horse-shoe permanent magnets, having their poles near together and being, moreover, fairly long as a rule, have not a very great self-demagnetising force, even without the keeper. With the keeper on it is of course practically *nil*, and will retain its magnetism for an indefinite period. The cores of electromagnets again, vary in self-demagnetising force in just the same way, and for the same reasons. A long core or a horse-shoe having this force to a small extent only, takes an appreciable time for the flux of induction to fall on the cessation of the current, from its maximum to a given fraction of the maximum, and retains a large percentage as residual magnetism. For this reason the magnetic circuits of fast speed telegraph instruments are made with gaps of considerable magnetic resistance so that they may be rapidly demagnetised, and yet not of too great resistance, for the instruments require to be sensitive to feeble currents. Instruments which are required to work sluggishly, on the other hand, are made with the very smallest resistance air gaps. This in itself, however, would not render them sufficiently sluggish, so the coils are supplied with a shunt of appropriate resistance through which on any rapid disturbance of the magnetism the "extra" current circulates which is generated in the coils, and thus puts a damper or brake on the disturbance and allows the hysteresis of the iron to come into play, which having but a small demagnetising force to cope with, allows only a gradual subsidence of the induction.

It must not be assumed that the self-demagnetising force of any magnetic circuit is a constant for that circuit, for it necessarily varies with the flux of induction through the

* Electrical Review, Vol. xxxi., p. 428.

circuit. Thus, if there is the same total induction, B, through a short thick bar magnet as through another of the same length but much smaller section, then the latter has a much greater maximum $\frac{l}{a}$ than the former, and, therefore, a much greater self-demagnetising force—a condition of affairs which is just reversed when the respective magnets have equal inductions per unit area of section. In the case of electro-magnets the flux of induction is increased until the magnetising force is balanced by the demagnetising; so that in speaking of the self-demagnetising force of a magnetic circuit, we must think of it in relation to the induction.

It has been mentioned that in the magnetic field of any magnet $\frac{l}{a}$ is not the same for all tubes of force. For the most important part of the system, viz., where the density is greatest, however, this may be taken as equal for all tubes. As we get towards the neutral zone of the bar or horse-shoe, as the case may be, the potential falls, so that we get a distribution of the tubes of force somewhat resembling the lines of current flow in a conducting liquid which has a bare wire conveying a current, partly immersed in it; this being a well-known analogy.

With regard to the nature of magnetism, it seems highly improbable that, as some have suggested, the state of being magnetised consists merely in a sort of spinning or rotational movement, in or of the ether, and that magnetic energy is therefore wholly of the kinetic kind; for if this were the case it would be difficult to see how a self-demagnetising force could exist, that is how the magnetised matter could restore itself to the normal unmagnetised state. Although it is likely, and even probable, that rotational motion has much to do with it, it seems fairly certain that there is some sort of strain in conjunction therewith.

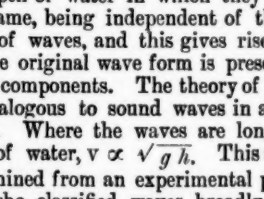
The iron or steel in any magnet has had the power imparted to it of maintaining a field in the air around. That is the important point. It is the external field which exhibits all the phenomena of attraction and repulsion. It is in the air that the force is exerted. This is a simple deduction from the law of the conservation of energy, but it cannot yet be said to be widely recognised.

WAVES AND VIBRATIONS.

III.

In his third lecture Lord Rayleigh stated that he had been so far considering waves whose length was small in comparison with the depth of water in which they occurred. The velocity is the same, being independent of the wave length, for other kinds of waves, and this gives rise to an apparent simplicity, as the original wave form is preserved. There is no analysis into components. The theory of long waves is in that respect analogous to sound waves in air and they preserve their type. Where the waves are long in comparison with the depth of water, $v \propto \sqrt{g\,h}$. This subject was very thoroughly examined from an experimental point of view by Scott Russell, who classified waves broadly as positive and negative. These are indicated by figure 8. Where there

Fig. 8.



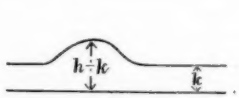


Fig. 9.

is a hump or crest the wave is +, and where it takes the form of a depression it is −. The height, h, being the elevation of the crest above, or maximum depression below, the general level. Positive waves are much more permanent phenomena than the other. Scott Russell and Airy held different opinions on this subject, and the discussion between them became almost a controversy. The latter embodied his views in the classical article "Tides and Waves," contributed to the *Cyclopædia Metropolitana*. Airy based his arguments upon the assumption that the height of the wave could be treated as very small. In this case, however, the practical man saw further into the matter than the theorist. The facts were, however, reconciled more nearly with theory or theory explained the facts and represented them better if the height of the wave be taken as $h + k$, as in fig. 9. Here the matter rested for about thirty years without an explanation being given, when Lord Rayleigh being interested in the subject took it up and worked out a full treatment. He found, however, that a French physicist had "very objectionably done the same thing five years before." One can understand the feeling of the lecturer in making this remark, no less than the laughter with which it was greeted.

Waves in canals often travel considerable distances. One observer states that he has followed a wave on horseback for several miles. Scott Russell's attention was first drawn to the subject by a canal incident in which a towing horse ran away taking the tow-boat after him. It was then seen that the resistance to motion was less at high than at lower speeds; the foaming stern waves had ceased. This was turned to mercantile advantage, and led to a large increase of business to the Canal Company, speeds of seven, eight and nine miles per hour being finally attained. The advantage gained was due to the higher speed, inasmuch as no wave could keep up with the moving mass. This part of the subject was done full justice to by Lord Rayleigh who described some of the features of canal propulsion and the bearing of these upon wave motion, as well as the latter upon the former.

Passing to the most important kind of wave motion in water—the tides—it was shown that long waves of the kind considered recur in intervals of 12 hours, and not in intervals of 24 hours. They are due to the attracting force of the sun and moon, mainly the moon, on the waters of the earth. Kepler was the first to establish this fact, which did not find favour with Galileo, who strongly expressed his disbelief. The action of the sun and moon is to draw away a large amount of water from the intermediate regions of the earth, the result depending upon the difference of the pulls of the moon and the solid earth, and being explained on this basis. The tidal wave follows the moon round and produces tidal effects. Difficulties arise and disturbances are caused from the shape of the land and the irregular depths of the sea. The simplest case postulates the action taking place over a single strip by imagining the ocean is limited to a single canal stretching round the equator. Airy solved this problem and solved it completely and satisfactorily, but whether it be high or low water under the moon depends entirely upon circumstances, as was shown. If the depth of water be more than 14 miles it would be low water under the moon. If the water were exactly this depth the tides would be enormously magnified.

IV.

Lord Rayleigh passed on to consider "jets" in his fourth lecture. If water be allowed to issue under pressure from a circular orifice, the jet ultimately resolves itself into drops. If the orifice be elliptical the jet takes the form of the orifice at first, but if the section be examined from its origin outwards it is found to become eventually circular. Also, if the major axis of the elliptical orifice be horizontal, initially the major axis of the jet will be horizontal likewise, becoming circular later and finally changing to an elliptical section with the major axis vertical. A further set of changes may take place. These changes were first examined by an Italian physicist. It has been observed that after one or two changes from horizontal to vertical elliptical sections the jet assumes a circular section, again becoming elliptical, and this ellipticity goes on increasing more and more, resolving itself into a thin sheet of water. If the orifice be triangular it may expand itself into three sheets in planes perpendicular to the apices of the triangular orifice. This can be explained in the same way that the plane of separation is formed when two jets meet each other full, a device often adopted in artificial ornamental fountains.

Capillarity has an important bearing upon the question.

The effects of capillary force appear to be due to the skin surrounding a liquid tending always to contract and reduce the surface to the utmost. For a given volume the surface is, of course, least when the section is circular, and this in some cases causes a jet to settle into vibrations about the spherical figure, inasmuch as a jet originally elliptical tends to become circular, it overshoots the mark, returns and finally reaches the circular figure. This was abundantly proved by some experiments in which the image of the jet was projected upon the screen. Knowing h, the head of water producing the jet, and g, the gravitational attraction, v, the velocity, could be calculated and the time of vibration of a cylindrical jet obtained. The calculation could even be turned to determine the capillary tension of the liquid, and to investigate the question whether the capillary tension has the same value at the time of formation of a jet as afterwards. Marangoni employed this method in some experiments upon soapy solutions, which have about one-third of the capillary tension of pure water. If the test be made by the usual method, and the rise in a fine capillary tube be measured, the capillary tension appears to be very nearly independent of the amount of soap in the water. The formation of a real skin may be something requiring time for its development on the surface from the interior, and hence the value of the jet method of experiment.

In going on to consider what happens when the orifice from which the jet issues is circular, Lord Rayleigh stated that this was really the most difficult case. The jet does not for long retain its integrity, it breaks up into drops. Prof. Boys has carefully examined this point by means of quartz fibres dipped into castor oil, but everyone is acquainted with the actual fact, as shown by liquids when dropped upon a sheet of glass, a plate, or a piece of paper. It is all a question of varicosity, leading eventually to the formation of distinct drops while the ligament becomes a spherule. Fig. 10 shows

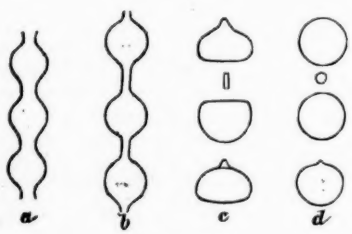


Fig. 10.

something like what happens, the varicosity is marked at a, at b the drops are connected by ligaments, at c the drops have actually separated, and at d the ligament becomes a spherule. The critical wave length of the varicosity is equal to the diameter of the jet.

The action of an electrified body upon a jet at the place where it resolves itself into drops was then shown. To account for this two theories have been advanced. The first assumes the attraction between two adjacent drops, which cannot be always of equal size, or equally electrified, to be the determining cause, leading to union instead of rebound. In the second explanation, which Lord Rayleigh favours, the fusion is accounted for by the actual passage of electric discharge from one drop to the other. This would perforate the skin and lead to coalescence. A pressure of two volts is sufficient to do this. The discharge would be due to a difference of electrification. It was demonstrated that if an electrified body, say a piece of sealing wax excited by friction, be brought near a jet the breaking up into drops does not take place as readily as it otherwise would do. The seat of the action is the point at which resolution would take place, the mere presence of the sealing wax at the point of issue of the jet has little or no effect. The resolution of a jet, left to itself, into drops, is somewhat irregular, and the spherules move with a different velocity to that of the drops. The resolution into drops may be hastened by the presence of a tuning fork, or, as in Chichester Bell's telephone experiments, by the sound waves set up when the drops are permitted to fall upon a diaphragm of membrane. The result is a kind of musical cycle. By a modification of this principle, Helmholtz employed a tuning fork of 128 periods per second, and Lord Rayleigh has himself obtained a current of over 1,000 intermittencies per second on which to use the telephone as an observing instrument. The arrangement for the latter purpose was exhibited, the telephone giving out a perfect roar. The drops as they fell closed the circuit of a battery and the telephone. The arrangement was devised in 1876, and in that year and in 1879, Lord Rayleigh submitted papers to the Royal Society dealing with work carried out by its aid. This is *the* ideal arrangement for use with the Kohlrausch bridge; under 500 ~ per second the telephone is of little use as a detector of balance on the bridge arms.

We have held over the remarks made by the lecturer on sound, as they were taken merely to vary the ideas spoken of, and although they served the purpose admirably at the lectures, it will be better to classify the branches of the subject a little more when they appear in print.

FILLING IN THE VALLEYS.

By H. J. DOWSING.

The articles in a recent number of the New York *Electrical Engineer* on "The Next Step," and "Electrically Heated Apparatus," by H. Ward Leonard, are interesting as indicating the direction in which they are looking in America for an extended use of electricity, particularly during periods of light load. The field for electric heating is undoubtedly a very wide one, and, if properly covered, would mean great things for the supply companies. It would do more than anything else to help fill up the "valleys" and level the load curve. For several years past I have persistently advocated the use of electricity for producing heat, particularly for domestic purposes, and it is only now that the matter is being seriously considered by those it most concerns. The idea of expense (which is often greatly exaggerated) appears at first sight to put electric heating out of the question, but a closer examination shows that it is not such a "bogey" after all. If we looked at the actual cost of a thing without other considerations, we should act very differently to what we do. Thus we should buy the *cheapest* food, we should ride in the *lowest* class, and indeed dispense with all our luxuries. It may be cheaper to walk a couple of miles than to ride, but he who loses ten-times the cost of the ride through loss of time can scarcely be considered a wise man.

Now, health is the main object, and our social life is guarded most zealously by local authorities and sanitary boards, armed with powers to prevent danger to our own health or that of our neighbours. We are compelled to have rooms of a certain size, suitable ventilation, and a great deal of work in connection with our houses which might be "done on the cheap" is forbidden. I am doubtful whether an excessively "cheap" man, who did not object to suffocation and a few other evils, would be allowed, even if he wished, to revert to the plan of our ancestors of placing an open fire in the middle of the room, and allowing the smoke to escape by a hole in the roof. Undoubtedly, this would be the most *efficient* way of warming, and it would simply be following the method of warming rooms and public buildings by using the gas burners now fixed for lighting. Of course, it is cheap in a way—contaminated water may be cheap, but it is not eagerly sought after. It's the after effects which make it dear. Until folks learn to look these matters squarely in the face, it is hopeless to expect them to see that what appears cheap at first is often dear in the end. Electric heating, despite the present cost of current, can even now, in some instances, compete with other systems.

Wherever short periods of heating are required electricity has its chance. Thus, in theatres and public buildings four hours, probably three, represent the time each day that heat is required. Coal and gas fires are entirely prohibited, hot air heating is not much in favour in this country, and the slow and inefficient system of hot water heating is the plan usually adopted. On the principle that it is wasteful to light a fire to boil only a kettle, so it is wasteful to light up a large heating system which may require hours to reach the necessary temperature in order to warm the building for so

short a time. A system costing twice or even three times as much per unit of heat generated in the theatre may be cheaper than one which loses 70 or 80 per cent. of the heat of combustion up the chimney and 50 per cent. of the remainder in transmission. It must be remembered that the majority of boilers used in hot water heating do not approach the efficiency of the ordinary steam boiler. They are stoked by unskilled persons, and their sole object is to obtain the greatest heat with the least possible trouble. In many cases it is found better to keep the furnace going day and night, and then we hear of fires from overheating of the flues. In using electricity all elements of danger are eliminated, for even the combustion takes place at the central station. Boilers soon become unsafe from incrustation and burning, and the pipes rust out when not in use. On the other hand, the electric conductors and radiators show no appreciable signs of wear when not in use, and the durability when used will probably be greater than that of any other system. If the cost of running should be a little higher, the advantage of always having the means of producing heat at a moment's notice and of perfect regulation, with absolute safety, should make electric heating popular. Many theatres are without any means of warning whatever, and to instal the old system, means cutting about in a serious manner to make room for the pipes, but electric wires may be run with comparative ease through the fire-proof walls, ceilings, &c. City offices are frequently supplied with coal at 1s. a scuttle. As much as three scuttles will be required on a winter's day. This 3s. would pay for 12 units of electricity, *i.e.*, nine hours' use of a large electric radiator, taking 1¼ units per hour. This radiator would warm an office 20 feet by 12 feet by 10 feet high, and maintain the temperature at 60° F. The electric radiator could be made even more efficient than a coal fire, as it would be placed in the centre of the room where heat was most needed.

Mr. H. Ward Leonard in his interesting tables of equivalents gives a mass of information which every engineer should be acquainted with. It is this very knowledge which has led many to believe in the impossibility of electric heating. The *practical* acquaintance with the generation and utilisation of heat in the household is lacking. When November fogs are upon us some attention is paid to the subject, but the wasteful coal fire goes merrily on.

The average kitchen fire will burn 1 cwt. of coal per day in order to extract an amount of heat equal to that produced by the combustion of 11 lbs. only. The work entailed in getting this 10 per cent. efficiency is altogether out of proportion to its value. The heat, smoke, and smell, together with the dirt generated in the kitchen, might all be dispensed with if the heat were produced by electricity. At the present rates charged by the companies the cost of each heat unit would be more, perhaps double or even three times the price of coal, but the saving in labour and the convenience would eventually make up for the extra cost. This, however, necessitates a revolution in the kitchen, and social revolutions of this kind are not brought about very quickly. I believe that if the companies would sell electricity at a little above works' cost for heating purposes, the new system would become popular at once, but at the fourpenny rate cooking by electricity will extend only in those quarters where a certain value is set upon the convenience. For warming purposes I believe there is a considerable field even at the present rates, and this is proved by the many enquiries and orders received for this class of apparatus.

With a greater demand for electrical heating and cooking apparatus the cost of production will decrease, but a large demand cannot be expected unless the charge for electricity is favourable.

Mr. H. Ward Leonard in his article calls attention to the fact that electrical heating arrangements, such as soldering irons, should be as small as possible, so that they may heat up quickly, and there may be little surface exposed to cause loss of heat by radiation. Mr. Leonard's suggestion is a good one so far as it goes, but economy in the use of current is not the only object to be sought, and my experience leads me to believe that durability of the apparatus itself is at least as important. When a very small mass of metal is heated rapidly, it is absolutely necessary to turn off the current immediately the iron is out of use, otherwise it will overheat itself. This is exactly what does happen with the majority of small electrically heated soldering irons. In order to overcome this difficulty I have worked out an automatic switch which will cut off the current when the iron has reached a certain temperature. This switch, however, adds considerably to the cost of the apparatus itself, and is an objection to its use, although an arrangement of the kind would undoubtedly preserve the iron from failure. The same arrangement of automatic control has been fitted to the electric oven, and with it the cook may turn on the whole of the switches and without attention be assured that the oven will not be overheated. The dial of the automatic switch may be set to any desired temperature. In the case of the soldering irons and small apparatus generally, I find that the larger the surface exposed will sometimes save the iron from destruction when the user has neglected to turn off the current. No doubt when electric heating becomes a little more common than it is at present, it will not be so difficult a thing to get people to pay attention to these small matters. At present, however, this inattention is one of the great difficulties we have to contend with.

It is a well known fact that the usual type of apparatus is not in every way suited for heating by electricity, and new types must be introduced. The prejudice to be overcome, however, is very great. It is probably a question of time, for I believe that when the many advantages of electric heating are known, it will be considered as much a necessity in the best class of house as the electric light is at the present time.

THE STORAGE OF ENERGY ESSENTIAL TO ECONOMY OF WORKING IN CENTRAL STATIONS*

By N. W. PERRY, E.M., New York.

(*Continued from page* 346.)

Steam Storage System.

As illustrating the *modus operandi* and cost of the system of "steam storage," as it is called, I quote from a report by Mr. Wm. Schonheyder, who, taking the load line of the Berlin electric lighting station as a basis, has figured out the relative costs of operation with and without a steam storage system. Fig. 1 is the load line of this station for December,

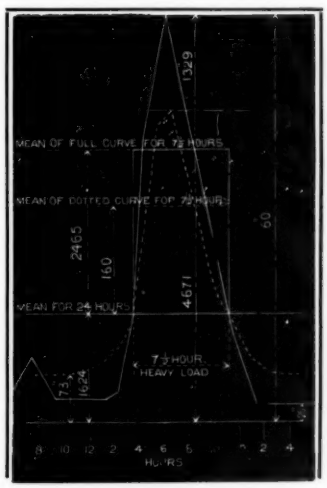


Fig. 1.

1891. The scale of the diagram is 1,250 kilowatts per ½-inch, and the water consumption is taken at 22 lbs. per kilowatt hour. Using storage tanks 8 feet in diameter, this would gave a scale for water consumption of 1 inch to

* Read before the National Electric Light Association at its 18th Convention, held at Cleveland, Ohio, February 19th, 20th, and 21st, 1895.

27,500 lbs. per hour. The maximum load is 7,500 kilowatts, requiring, say, 10,000 electrical horse-power. The minimum load, according to the curve, is 320 kilowatts, and the proportion of the maximum to minimum work required from the boilers will be as 7,500 to 320, or as 23·4 to 1. The mean load was 2,030. Excess of maximum above mean 5,080, or a load factor of about 27 per cent. Duration of maximum above mean 7·5 hours.

In estimating for the steam storage system, the extra quantity of steam wanted during 7½ hours, and which has to be produced from the water in the tanks, is represented by the area inside the full line curve, fig. 1, and the straight mean line for 24 hours. The boilers and tanks will, under this system, have to work at 250 lbs. gauge pressure, equal to 265 lbs. absolute for a large portion of the 24 hours. This extra steam then is 2·465 × 27,500 lbs. × 7½ hours = 508,200 lbs. at 130 lbs. absolute pressure as required by the engines, and this is equal to an expenditure of 508,200 lbs. × (1,219° − 376°) = 428,413,000 heat units − 376° being the mean temperature of the water from which the steam is produced, viz, 406° at beginning of heavy load, and 347° at the finish; 1,219° is the total heat of 130 lbs. steam. Since the water in the tanks, in producing this steam, cools from 406° to 347°, it gives up, say, 59 heat units per lb., and we shall therefore require $\frac{428,413,000}{59}$ = 7,261,000 lbs. water in the tanks. Taking the tanks, as before, as holding an available (steam room required at top) 750,000 lbs. each, we want $\frac{7,261,000}{75,000}$ = 97 tanks.

The necessary boiler power, compared to that of the present installation, will be in proportion of 1·624 to 6, and allowing, say, 5 per cent. extra cost for the increase in pressure, we get the cost of boiler plant with steam storage tanks equal to

Boilers	$\frac{1·624}{6}$	× £30,000	× 1·05	= £8,526
Tanks	97	× £500	× 1·05	= 50,925
		Total ...	...	£59,451

This is nearly double the cost of the existing plant, but as we will see later, the saving in fuel and in other ways makes the increased investment pay when fuel is dear.

The Feed Storage System.

According to this system, approximately the whole of the feed water required for the 24 hours is pumped into the feed tanks during the time of light loads; so much of it as the boilers require during this time is supplied from the tanks, and the rest (which will be that wanted during the heavy load time) is retained in the tanks and heated up by the surplus steam during the said light load time up to, or nearly to, the temperature of the steam in the boiler, viz., 347°, and is used as boiler feed during the heavy load.

By this method of working the duty required from the boilers will be considerably lessened, for, while during the time of maximum load they will still be required to supply steam at the rate of 6 inches × 27,500 = 165,000 lbs. per hour, the total heat which they have to gather from the fuel and impart to the water will be lessened by the increase in temperature of feed from 100° to 347°, a gain of 247°. The total heat of 130 lbs. absolute steam being 1,219°, we have the maximum heat to be supplied by the boilers at present = 165,000 × (1,219° − 100°) = 165,000 × 1,119 = 184,635,000 units of heat hourly. Whereas with the feed storage the maximum required = 165,000 × (1,219° − 347°) = only 143,800,000 units. In other words $\frac{1}{4·53}$ of the maximum work of the boilers is avoided, and a corresponding number can therefore be laid off.

During every stage of the heavy load, with 347° feed, the same proportion of boiler work is saved, and this is illustrated on the diagram by the dotted curve and figures, 4·67 inches representing the maximum required work with feed storage, against 6 inches without, equal to a gain of 1·329, which is $\frac{1}{4·53}$ of 6·11, or 22 per cent.

The dotted curve of required boiler duty, during the 7½ hours under the new conditions, is, therefore, quite definite as to form, and also as to area enclosed by it. The dotted curve during the remaining 16½ hours of light load must be such that the deficiency in work during these hours equals the excess of work during the heavy load time, and the area it encloses is, therefore, quite definite, while its form depends upon the rates of working both as to firing and to feeding, and this form can with moderate care be made to assume that shown, which will give a maximum amount of work measuring 0·73 inch, so that the ratio of maximum to minimum becomes six to one, viz., $\frac{4·671}{·73}$, instead of the present 23·4 to 1; a reduction of irregularity of working which must necessarily be beneficial to the general working of the boilers, and must effect a considerable saving in fuel.

The required tank capacity is easily estimated, being the total of water evaporated for 7½ hours, viz. (1·624 + 2·465) × 27,500 lbs. × 7½ = 843,150 lbs. Taking the size of tanks proposed by Mr. Halpin of 8 feet diameter by 30 feet in height, and allowing for their not being emptied within some 3 feet of the bottom, so as to leave room for deposited mud, &c., they may each be taken as containing a working quantity of 75,000 lbs. of water, so that full 11 of them would be wanted, viz., $\frac{843,150}{75,000}$ = 11·24.

The cost of these, including fittings and coverings, I will take at £500, which I believe to be a liberal estimate, so that if we allow for a reduced number of boilers, according to the reduced maximum work required for them, we shall have the cost of boiler plant on this system:

Boilers	$\frac{4·671}{6}$	× £30,000	= £23,360
Tanks	11·24	× £500	= 5,620
		Total	£28,980

Combined Feed and Steam Storage.

The same authority gives the following estimate of cost of this as follows:—The saving of boiler duty, due to the feed storage only, is the same as for the previously taken case of feed storage, and is represented by the area enclosed between the full and the dotted curves during the 7½ hours of heavy work, and the extra steam to be produced is represented by the area enclosed between the dotted curves during the 7½ hours, and the straight mean lines for 24 hours. This extra steam will amount to 1·60 × 27,500 lbs. × 7½ hours = 330,000 lbs., requiring 330,000 × (1,219° − 376°) = 278,190,000 heat units. The water in tanks giving us, as before, 59 heat units per pound in cooling, we shall want $\frac{278190000}{59}$ = 4,715,100 lbs. of water, which will require 63 tanks. Add tanks for feed storage as before = 11 = total of 74.

The boilers will cost as for steam storage	...	...	£8,526
The tanks will cost 74 × £500 × 1·05	...	...	38,850
Total cost ...	...	...	£47,376

This is over 20 per cent. less cost than for the steam storage alone. It is not more complicated, since the feed and the steam may be stored in the same tanks; and it has the additional advantage of supplying nearly clean water to the boilers, as has the simple feed storage system, and the work on the boilers is uniform for the 24 hours, which will necessarily produce a considerable economy of fuel.

Comparing now the above four modes of working the boiler plant of such an installation as the Berlin electric station and tabulating Mr. Schonheyder's results we have the following tabular view:—

	Present System.	With Feed Storage.	With Steam Storage.	With Feed and Steam Storage.
Steam pressure	115 lbs.	115 lbs.	115 to 250 lbs.	115 to 250 lbs.
Feed temperature ..	100°	100° to 347°	100°	100° to 347°
Rate of working	23·4 to 1	6 to 1	Uniform.	Uniform.
Feed water	Dirty.	Clean.	Clean.	Clean.
Cost of boilers	£50,000	£23,360	£8,526	£8,526
Cost of tanks	..	£5,620	£50,925	£38,850
Total cost.....	£30,000	£28,980	£59,451	£47,376

All of the above was embodied in an article of mine published in the *Western Electrician*, of January 5th, 1895.

(To be continued.)

ALTERNATE CURRENT MOTORS.

By W. G. RHODES, M.Sc.

Since the Frankfort Exhibition in 1891, a great deal of attention has been given to alternate current motors both on the continent and in America; in England, however, but little has either been done or said with regard to them.

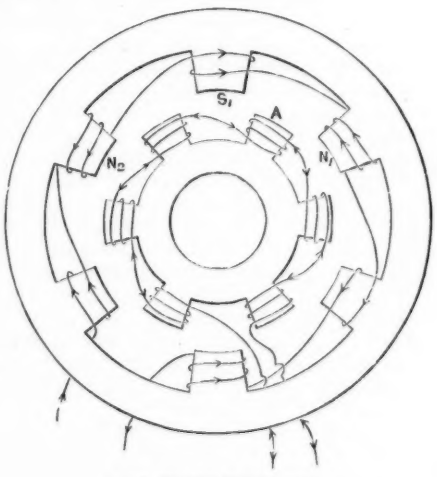
The subject was brought before the Institution of Electrical Engineers by Mr. Snell in 1893, but the discussion there tended to discourage the use of such motors, the chief objection being the low frequencies at which the machines were then constructed to run, and which rendered them inefficient on circuits intended for both the distribution of power and alternate current lighting. Rapid strides have since been made in the construction of alternate current motors, and machines can now be constructed to run at any desired frequency, within wide limits, and at the same time have a very high efficiency.

The tendency, nowadays, to transmit electrical energy at high potentials, such as 10,000 or 20,000 volts, practically necessitates the use of alternate currents, since the commutator—a necessary adjunct of a direct current dynamo—could not stand such high voltages; so that, apart from the fact that there is considerable saving of copper in the transmission mains, and ignoring altogether the question of efficiency, if we work at such high voltages we are compelled to generate and transmit alternating currents, and, consequently, to use alternate current motors. Thus the question of the desirability of working at high voltages depends upon whether we can produce good alternate current motors.

A good motor, whether for direct or alternating currents, should be strong, and, at the same time, not too heavy; it should have a simple mechanical construction and should be convenient in form; its speed should be under perfect control, that is, it should be able to run at constant speed, and also be capable of considerable variations of speed; it should be self-starting, and its torque should be great at starting and should diminish as the speed increases; it should be capable of sudden violent exertion, and of changing its direction of rotation without difficulty; it should run cool and stand overloading without danger; it should not take too large a current at any time, and it should have a high efficiency at widely varying loads.

We can well imagine that to get all these qualities combined in a single motor is extremely difficult, but we shall, I think, see that alternate current motors can be constructed to give very satisfactory results, taking as our ideal motor one which satisfies all the above conditions.

Alternate current motors are either *synchronous or non-synchronous*.



—→ Signifies direct current.
←-→ Signifies alternating current.

Fig. 1.

Synchronous Motors.—Imagine the field of an alternate current dynamo excited by a direct current, so that the poles round the field are alternately north and south, and suppose an alternating current sent through the armature coils. Suppose fig. 1 represents the relative positions of the field and armature when at rest. The pole, A, of the armature is alternately a north and a south pole; when a north pole it is repelled by the pole, N, of the field, and attracted by the pole, S, and consequently there is an impulsive force tending to move the armature in the counter-clockwise direction; the next instant, however, A is a south pole, and an impulsive force tends to move the armature in the clockwise direction; the result is that the armature is not moved at all. These alternating impulses follow each other with a rapidity depending upon the periodicity of the alternating current; the time which elapses between any one impulse, and the next being half the periodic time of the current.

Let the periodic time of the armature current be τ, and suppose that by some mechanical means the armature is rotated at such a speed that in time $\frac{\tau}{2}$ the pole A is moved through the distance between two consecutive field poles. When in the position represented in fig. 1, if A is a north pole, the impulse acts in the counter-clockwise direction, in time $\frac{\tau}{2}$ A is a south pole, and is midway between S_1 and N_2, therefore the next impulse is still in the counter-clockwise direction. Hence, if the armature is by some means rotated at such a speed that an armature pole moves through the distance between two field poles in half the periodic time of the armature current, and then left alone, the reaction between field and armature will keep up the rotation and the machine will run as a motor. When this speed is attained the armature is said to be "in step" or "in synchronism" with the alternating current. Moreover the machine will continue in step under loads which may vary within certain wide limits, depending upon its mechanical construction and on the magnitude of the current passing through the field coils and also upon the magnitude and frequency of the armature current; so that once in step the motor will continue so unless the load limit is passed, in which case it will suddenly stop. We see, therefore, that such a motor is identical in principle with an alternate current dynamo, and could be used as a dynamo just as a direct current motor can be used as a direct current generator.

The chief characteristic of the ordinary alternate current machine run as a motor, is that, to run at all, it must be in step with the current through its armature, and, therefore, having given the frequency of the alternating current, the speed of the motor is absolutely fixed. We reserve the name "synchronous motor" for such as will run when in synchronism, and only when in synchronism, with the current from the generator which drives them.

In working with synchronous motors, the chief difficulty is in starting. The usual method of procedure is as follows: The field is excited by a suitable direct current, the magnitude of which will depend on the motor to be used, and must be ascertained by trial. The motor is driven mechanically until synchronism is attained, and then the armature current is switched on and the mechanical driving power removed; if this is done exactly when synchronism is attained the motor will continue to run. In order to know when the motor and the alternating current synchronise we may use the following method, due to Prof. Ayrton and Mr. Mather, which is simple and, at the same time, very effective.

Let M (fig. 2), be the motor, and D the distant dynamo; let V be a hot wire or an electrostatic voltmeter, and, when working at high voltages, let R be a high resistance, and let the connections be as represented in the diagram before the alternating current is sent round the motor armature. Then

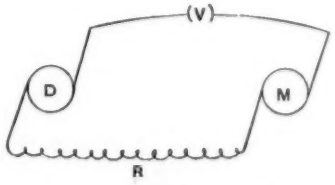


Fig. 2.

it is easily seen that when the motor and generator are not in synchronism, the difference of potentials at the terminals of the voltmeter will oscillate with a rapidity depending on the rate of change of the difference of phase of the E.M.Fs.

C

of generator and motor; and the voltmeter needle will oscillate accordingly. The oscillations will become slower and slower as the speeds approach synchronism, and when synchronism is exactly attained the needle will be steady and will have a minimum deflection.

A gold leaf electroscope makes an excellent synchroniser, and might replace the voltmeter, the machines being connected respectively to the outside of the jar and to the gold leaves.

The above method of obtaining synchronism is obviously applicable to the general case of any two alternate current machines, whether both generators, or one a generator and the other a motor.

Having given the general principles of the synchronous motor we proceed to investigate its electrical properties more in detail.

Theory of the Synchronous Motor.

Let R be the resistance of the motor armature.

S = its reactance [$= 2\pi n L$, where n is the frequency of the alternations and L is the self-induction coefficient of the armature].

I = impedance.

E = impressed E.M.F.

e = counter E.M.F. of motor.

c = effective value of current in the armature.

p = total mechanical power given out by motor.

e_0 = E.M.F. to overcome self-induction and resistance of armature $= I c$.

ϕ = difference of phase between c and e.

θ = difference of phase between c and e_0.

Then we have

$$p = c\, e \cos \phi \quad \text{and} \quad \cos \theta = \frac{R}{I} \qquad (1)$$

Also, since the E.M.Fs. E, e, e_0 are in equilibrium amongst themselves, we have—

$$E^2 = e^2 + e^2{}_0 + 2\, e\, e_0 \cos(\theta - \phi). \qquad (2)$$

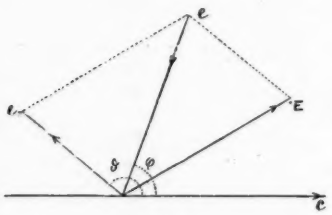


Fig. 3.

Eliminating θ and ϕ between equations (1) and (2), and remembering that

$$I^2 = R^2 + S^2$$

we have

$$E^2 - e^2 - I^2 c^2 - 2\, R\, p = 2\, S \sqrt{c^2 e^2 - p^2}. \qquad (3)$$

This relation is due to Steinmetz, and is called by him the fundamental equation of the synchronous motor.

(*To be continued.*)

THE PURIFICATION OF WATER BY ELECTRICAL PROCESSES.

The electrical purification of water and sewage appeals to the general public as a process likely to be both potent and effective, for they have been accustomed to think of that subtle form of energy which we call electricity, as "a force which purifies as well as destroys." It is idle, perhaps, even now to attempt to educate those who have no real knowledge of science up to the correct use of terms, or to point out that in no commercial process for dealing with water or for sewage disposal, hitherto proposed, does electricity play the part of a directly active agent. Nor can we expect the layman to be accurate so long as the electrical engineer, in appealing to him for financial support, continues to be guilty of the use of misnomers and misleading descriptions, not, of course, with fraudulent intent, but with the notion of descending to a level where he will be understanded of the people. It is high time that such tactics were abandoned; they may serve to catch the ear of the multitude as a whole, but the more intelligent—and these comprise a growing class, fortunately—will only regard them with suspicion. The promoters of systems of water purification and sewage disposal have much to answer for in this connection, and perhaps "a word to the wise" will be sufficient.

Of the systems of so-called electrical purification of water, to which considerable prominence has been given during the last decade, two classes may be distinguished, namely: (1) Those which electrolyse water, liberating oxygen at the positive pole; and (2) those which electrolyse solutions of common salt, producing certain germicidal substances such as hypochlorites, which are subsequently mingled with the water to be purified. Thus it is evident that the electrical energy is employed in each class for producing substances which then act chemically upon the impurities contained in the water. We state this with no desire to detract from the importance of the part played by electricity in these operations, but simply with the idea of clearing away a very common misapprehension, which attributes to it the actual function of purification.

There is a general feeling amongst unbiassed experts that the possibility of oxidising the organic impurities of water on a large scale, and within commercially feasible limits, by means of oxygen liberated from the water by an electric current, will never pass beyond the borders of dreamland. Attractive as the process seems, the necessary conditions for accomplishing it could probably never be realised in the water supply of a great city. Moreover, other positive electrodes than oxidisable metal will have to be found if the oxygen which is liberated from the water for the purpose of attacking the organic matter in it is to be prevented from spending its energy in combining with these electrodes.

The more recent systems of water purification, in which electricity plays a part, belong to the second class, which involves the electrolytic decomposition of a solution of common salt. Some of our readers will perhaps kindly bear with us while we describe briefly the principles underlying these systems. When a solution of salt (chloride of sodium) is decomposed by electricity, sodium is liberated at one pole and chlorine at the other. The sodium is immediately oxidised, and combines with the water present, and a solution of caustic soda results. By suitable mechanical contrivances the chlorine gas may be conducted away from the other pole as fast as it is liberated. But if instead of separating the caustic soda and the chlorine from each other they are allowed to combine, a complicated series of reactions takes place, common salt is not reformed again, but various other products result, which depend, as regards their nature and amount, upon the concentration of the liquid, as well as upon its temperature. Under ordinary circumstances the principal product is sodium hypochlorite, and this is the substance which is relied on for rendering innocuous the organic matter of any water with which it is subsequently mingled in the form of an aqueous solution.

As we have already observed, when dealing with a system for purifying sewage (*vide* Electrical Review, August 31st, p. 250), there is nothing new in the application of electricity to produce hypochlorites, nor is there anything novel in the use of sodium hypochlorite as a disinfectant or germicide. The so-called electrical purification of water by treating it with an electrolysed solution of salt is simply a process of disinfection by sodium hypochlorite. Electricity as such has nothing to do with it: its function is merely to bring about the formation of the chemical, and there is nothing to be gained by christening plain, honest, hypochlorite, with some fancy name of mysterious import, such as "electro-this" or "electro-that."

We now reach the question whether it be desirable to treat a city's water supply with a powerful and soluble disinfectant like sodium hypochlorite. To this question Dr. Thomas M. Drown (to whose paper in *Technology Quarterly*, 1894, Vol. vii., No. 1, p. 51, we acknowledge our indebtedness) would evidently give an unqualified negative, and is of opinion that where a water supply has got into such a hopelessly bad condition that nothing will render it safe but disinfection by means of hypochlorites or other chemicals of that order, it is high time to abandon that supply. The

idea of chemical disinfection is repellant to Dr. Drown, and he considers it to be a foolish blunder to permit the pollution of water sources and then systematically to disinfect them.

For our own part, we confess to entertaining no sentimental objection to the chemical disinfection of a water supply, especially if it be the only supply available, provided that the operation of disinfection leaves nothing behind it. Can this be said of sodium hypochlorite? We think not; and that it comes under the category laid down by Dr. Frankland, F.R.S., in a book entitled "Micro-organisms in Water," published a month or two ago. This category includes substances which, being soluble, are chemically active, and are added in such quantity that a direct bactericidal effect is produced. Such treatment cannot, as a rule, be employed for the purification of drinking water, but is extremely useful in the disinfection of sewage. If those who propose to purify water by such means are ready with a system of precipitation which shall eliminate from the water every trace of hypochlorite after the latter has done its work upon the deleterious organic matter and germs, then these arguments fail to carry any weight. It matters not a little bit to the consumer what operations the water is subjected to, so long as he receives it eventually in a pure condition. Surely such a consummation is not beyond the range of possibility?

The purification of potable waters is, from the hygienic standpoint, of the same order of importance as the disposal of sewage. Given a good water supply and an efficient sewage system, and the death rate in our large cities never fails to fall. For years sanitary experts and faddists in hygiene have been wreaking their own sweet will upon the conditions under which we live; the resources of chemistry and of engineering have been tried to the uttermost, and yet the call is for more improvement. Electricity has proved so cosmopolitan in its applications, that it is at least reasonable to suppose that the great water question is not beyond its influence, whether it be used as a direct or an indirect agent. And the degree of success so far attained by those who have sought to apply it to the problem is certainly not discouraging. The lines upon which electrical engineers have hitherto sought its solution may not give promise of much result, or be desirable in their issue; but that is no argument for giving up the attempt. It remains for those who are interesting themselves in hygienic matters to follow up other lines of research; the subject is sufficiently interesting and important: whilst regarded from a purely sordid point of view, it presents every inducement.

ARGON: THE SUPPOSED NEW ELEMENT IN THE ATMOSPHERE.

IV.

Our readers, and likewise those chemists who have studied Rayleigh and Ramsay's paper, in *Nature* of February 7th, for themselves, will not be surprised to learn that argon has not proved to be inactive in the hands of M. Berthelot, the eminent French chemist, who appears to have concluded his recent communication to the French Academy with the gently sarcastic remark that the name "argon," meaning "inactive," is not a well chosen one. The drift of Berthelot's paper, as will presently become quite plain, is that the argon bubble has suffered complete collapse.

The Chemical Society decided the other day not to include Prof. Ramsay, but to limit its grant of the Faraday medal to Lord Rayleigh alone, so there is a certain appropriateness in the decision.

It was Rayleigh, and Rayleigh alone, who made out that the nitrogen of the atmosphere differs from the nitrogen of nitre by being slightly denser. To account for this the conception of argon as a constituent of the atmosphere was called for and about 1 per cent. of argon was required.

Rayleigh's modification of the Cavendish experiment exhibited this 1 per cent. of argon—by what means references to our former articles will disclose. Ramsay, on the other hand, was not so perilously successful, and argon in his hands dwindled down to one-twentieth of 1 per cent. In Berthelot's hands Ramsay's argon has dwindled down to almost nothing.

THE ST. PANCRAS EXPLOSIONS.

When we ventured to make a few remarks in a recent issue on the subject of the St. Pancras explosions, we were not so oblivious of our Æsop as to imagine that we should succeed in pleasing everybody. *Omnes amicos habere operosum est.* An estimable contemporary, with a prudence begat of past experience, declined to notice our comments on its attitude in regard to this matter. But we have learned to expect little virility from our estimable contemporary. That the organs, however, which represent those interests, generically designated by the term Gas, should have been disregardful of our flippancies, was not to be expected. Nevertheless, we occupy the same position as before the advent of their intelligent criticism, and we do not retract anything which we have advanced.

It is part of our functions, as an integral portion of the technical Press, to criticise and to sustain criticism. We are ready to scourge unscientific statements as severely as the occasion demands—as in the case of Major Cardew's official recommendations to the St. Pancras Vestry. If we are scourged ourselves, we will acquiesce with the best possible grace. *La fortune passe partout.* We contend that an official report, or letter, should be beyond rebuke. When, however, we find it wanting, we shall not be backward in pointing out the deficiency. Public officials maintained at the public cost, and public journals fidgetting for public support, must not be allowed to impose either wilfully or innocently upon public credulity; and however galling it may be to the objects of our remarks, it remains our obvious duty to insist upon accuracy.

One of our doughty critics attempts to pillory our capacity for estimating the value of evidence. There was little or rather no evidence to estimate. All we did was to insist upon a recognition of well-ascertained and classical facts, allowing that possibly sodium might be present in the substance extracted from the St. Pancras mains in a physical or chemical condition of combination, or otherwise, hitherto unsuspected by chemists. We did not suggest the source of the sodium, but we most emphatically did object to the source jumped at by our estimable contemporary, for it had no facts to go upon. Besides the glaze on the stoneware insulators, it was open to us to suggest sodium sulphate, sodium chloride, if not others of the salts of sodium which notoriously form some of the ingredients of London soil, and which frequently appear in the form of an efflorescence on brickwork. We do not deny the possibility, under given conditions, of forming metallic sodium or sodium compounds or alloys from these sources. And it is conceivable that at a certain physicological moment a globule of sodium, or even of potassium or of some alloy or compound of these metals, might be formed owing to electrical action; and that a degree of heat might be set up, during such chemical reaction as might be expected immediately to follow, sufficient to inflame a mixture of coal gas and air that might happen to be present in the mains. All this we say is conceivable but does not prejudice the position we advanced in our previous article.

It is not for us to sit down and evolve theories out of our own inner consciousness, like our estimable contemporary. Anybody can do that. We have profited sufficiently from our study of the history of scientific progress to be aware that theories if they are to be of any service in advancing knowledge, can only be born of generalisations, and generalisations of experimental facts carefully and intelligently collated during exhaustive investigation. Actually we have not even seen that ingenuous "specimen" which again and again bursts into flame so obligingly on the application of "a spoonful of cold water." Far be it from us then to formulate a theory; although a distinguished representative of the *Pall Mall Gazette*, with a want of lucidity rarely absent from its clever columns, has fathered upon us two *theories*, whilst in reality we only ventured to suggest two *theorems* for investigation.

But to return to our estimable contemporary. In its issue for March 8th it, with the most beautiful simplicity, published two letters, one from a Mr. H. W. Keiffenheim, and the other from Messrs. Doulton & Co., of which the gist of *both* support the contentions we advanced in our article, and to which such exception has been taken. We are not prepared to endorse all the arguments of these correspondents; but, such as they are, they only serve to strengthen

the position we took up. We tender our best thanks to our estimable contemporary for its fairness in publishing these letters. We are afraid, however, that it did not mean to be overpoweringly magnanimous.

But that is by no means all. With a smirk of satisfaction our estimable contemporary gives prominence to the following letter or note, communicated by one of its talented contributors or correspondents (or by what other euphemistic expression those who fill its columns are designated).

A Peculiar Ground.—A short while ago an incident happened in connection with the Edison three-wire system under Boylston Street, Boston, which is interesting both to the electrician and the chemist. It was noticed that the horses were very uneasy and somewhat scared when passing over an area of, say, 10 feet square in the granite pavement of the street. An investigation by the Edison people seemed to show no trouble, and everything went right for 10 days or more, when, during a rain storm, the same action of the horses was noticed. Upon digging down to the wooden box which contained the three wires of the system, embedded in some kind of tar or bitumen compound, a spot was found where the box was eaten through, and a large mass of sticky stuff was found around the negative wire. The insulation of the wire was destroyed, and as the neutral is dead grounded in the station, there was a leakage, causing a fall of potential in the earth about the leak which was sufficient to affect horses as well as men. The leak was a small one, and did not show at the station. Chemical examination of the lump showed that it was originally concentrated lye, which had become partly converted into caustic soda by water, and that the action of the currents had, by electrolysis, formed a considerable quantity of metallic sodium throughout the mass. There was sodium enough present to make a fair display of fireworks when thrown into a pool of water, and it is fortunate the workmen did not get into trouble in handling it. My theory of the affair is this: In some way a piece of lye tumbled into the kettle in which the insulating compound was made, and was not noticed when the box was filled. In time surface water got at this lump, and converted a part into caustic soda, which destroyed the box and insulation of the wire (it only came in contact with one wire, the negative). The escaping current caused a difference of potential at the surface of the ground, which disturbed the horses. Metallic sodium was set free and would tend to collect at the negative wire. The voltage at the escape was in the neighbourhood of 105 volts, and it was estimated by the touch that there was over 50 volts within the space that a man could reach with both hands.

It would be an insult to the intelligence of our readers to comment upon this effusion. The "note" from the *Scientific American* is given without authority, and the way of stating it is such as to condemn it at once in the mind of every clear-headed Englishman who knows anything about chemistry. No scientist could possibly tolerate this description of what is stated to have happened. It is sufficient to reproduce without comment this note which our contemporary obviously gloats over. We quote it as an illustration of the utter empiricism which we are asked to swallow. It would be a work of supererogation to attempt to analyse this remarkable statement of "facts."

The correspondence columns of the recent issues of our estimable contemporary would furnish us with plenty of excuse for "copy." In every instance it could either be used for supporting our own position with regard to the St. Pancras explosions, or could be flatly contradicted out of the most elementary knowledge. An itching to see one's name in print seems to overpower a certain order of mind. The letter which is probably calculated to be the most deadly, is that which hails from the Brighton Corporation Electricity Works. After a lot of irrelevant remarks about "shocky casings" and the like, the writer (he is supposed to be describing the behaviour of an "interesting specimen of capping" from his "museum of faults," which, having been extracted from the electric light culverts, did, to his "great bewilderment," give "brilliant but minute flashes of light from the under surface of the capping by drawing the finger over it") is careful to assure us that he has "but a mere smattering of chemistry." Having thus naïvely sized himself up—if we may be forgiven the expression—he proceeds to evolve a theory: "On hearing of Major Cardew's recent investigations," he says, "it now seems most probable that this curious phenomenon owes its existence to something akin to the presence of some unoxidised sodium or potassium kept in that state by the continued electrolytic action from the neighbouring wires."

This instance is on all fours with others which we might quote, but *ex uno disce omnes*. For our own part, before we would venture to commit ourselves to anything in the nature of a theory we should require to know the *whole* of the conditions of the case. These conditions should be tested by well ascertained facts, and only after having assured ourselves that everything, humanly speaking, had been defined would we permit ourselves to advance an hypothesis. The question of the St. Pancras explosions seems to be beset with difficulties of a purely chemical as well as of an electrical nature, and we cannot conceive any conclusion being adventured until the whole of the electrical conditions shall have been ascertained, and analyses shall have been made of the atmosphere of the culvert and boxes, the deposits on the brickwork, the copper conductors, the stoneware insulators (not to mention the condition of the wooden wedges introduced to prevent sagging), the soil, and the liquid which appears everywhere in the form of "moisture." The commissioners appointed by the Board of Trade, acting in conjunction with the Royal Society and the Institute of Electrical Engineers, will have had every opportunity of ascertaining these vital points, and upon their final report we wait with considerable interest.

Notwithstanding the hubbub which our previous article has excited, no one has yet attacked our main position. One journal, it is true, has invoked the shades of Dr. Syntax over a single line, whilst another has been good enough to compliment us upon our "brilliant sarcasm." This is kind; and we wish we could congratulate the latter on the brilliancy of its illuminant, just as a matter of courtesy. We contend that our position has not been assailed. We exercised the right to cavil at the unscientific statements contained in the official utterances of the Board of Trade, and to be amused at the gullibility of our estimable contemporary. We drew attention to certain classical chemical facts about sodium, and suggested that the statements of our contemporary, and the recommendations of the Board of Trade, were not in harmony with them. We objected to the hasty inferences drawn. We complained of the unscientific diction; and, pointing to the raw material, or *vis viva* of the explosion, we suggested that it was desirable to strike at the source of these explosions, viz., the leakage of coal gas.

It is claimed that the gas companies are only too anxious to eliminate leakage; and we will willingly admit that the problem of prevention is an exceedingly difficult one. In the strictly ethical aspect of the question, however, gas, to the extent of 10 or 15 per cent., has no business in an electric lighting culvert or junction box, and those who permit such an accumulation are without doubt culpable and morally responsible for any evil which may ensue. In putting this forward we do not shut our eyes to the fact that it is incumbent upon those who dispense electric light to prevent or do their utmost to prevent everything which can be regarded as in the nature of a proximate cause of explosion. A share of onus lies on each side; and though a sort of double-edged danger usually lurks in a proverb, we may certainly indorse the claim of another worthy contemporary, namely, that "prevention is better than cure."

We have by no means said all that is in our minds to say concerning this question; but space is limited, and assuming that our readers are already familiar with what we have previously given vent to upon this subject, we conclude with the statement of a hypothetical case.

Let us assume that a person permits a few hundredweights of loose gunpowder to be promiscuously stored somewhere in the basement of his offices. And suppose that the match, wherewith a postprandial cigarette were lighted by a casual passer-by, were thrown down amongst the aforesaid promiscuously stored gunpowder, with the result that an explosion ensued. Who will be answerable in the eyes of the law? The wretched individual who lit his cigarette, and threw away his match without thinking, or the person who permitted gunpowder to be stored in a place in which it had no business or license? The proximate causes of the various explosions which have hitherto taken place have been varied, but the source of the explosive mixture has always been the same, viz., the mingling of air and coal gas. If we can only remove or prevent the accumulation of the explosive material, we need not worry ourselves concerning the proximate causes which condition an explosion. In other words, by a different route of reasoning, we find ourselves, in spite of criticism, in precisely the same position which was defined in our previous article. Nevertheless, since we are extremely doubtful whether the gas companies are in the slightest degree equal to the task which, ethically speaking, should be imposed upon them, we must not disguise from ourselves how incumbent it is upon those who dispense

electric light and power to do their utmost to reduce, and, if possible, to eliminate, everything that can be regarded as in the nature of a proximate cause of explosion.

CORRESPONDENCE.

The Electrolysis of Gold.—The Critics Criticised.

A contemporary publication recently expressed the hope, in referring to my paper having for a title the first part of the above title, "that the dreary controversy . . . . may not be revived either by Mr. Andreoli, or by anyone else." Evidently, then, some people think that Mr. Andreoli should stop his unpleasant habit of controversy. I think so—for his own benefit, at least. In this matter I feel like the big man whose little wife practised beating him with the household rolling-pin, and he didn't stop her, "because it amused her, and didn't hurt him."

But he bobs up, now, in these columns as a spiritualistic medium for something he calls after the immortal Faraday, who is "horrified" at the phrase, or title, *The Electrolysis of Gold*. Further on in the same number of the Electrical Review, Mr. D. G. FitzGerald sets forth his *previously suppressed* objection to the same.

In the interests of etymology and electrology, let us understand whether I was wrong in my expression. According to the lexicographers, the word *electrolysis* is formed from two Greek words: Electron, from which the word electricity is derived, and "lusis" (λυσις), a release, or setting free, a derivative of the word "luein" (λυειν), to dissolve, to loose, to set free. Therefore *electrolysis* is the dissolving, loosing, or setting free, alternatively or collectively, of a substance by means of electricity.

Webster's "International Dictionary" defines the word as follows:—"The art or process of chemical decomposition by electricity, *as in the electrolysis of silver or nickel* in electroplating."

I wonder if Mr. Andreoli's bogus Faraday, or if Mr. FitzGerald's "Institution of Electricians," objects to Webster's *electrolysis of silver*, because, in the language of Mr. FitzGerald about gold, "Silver, if not an element, has at all events never yet been resolved into components—that it had not been analysed, and that consequently it cannot have been electrolysed." What is to become of the commonly used phrase, "Analysis, or assay of gold"?

I think, with Mr. Andreoli, that "electricians ought not to speak loosely about electrical matters," therefore I selected my title with due regard to etymology and the scope of the paper, and thereby have horrified Mr. A.'s bogus Faraday, who causes him to make himself ridiculous by trying to speak for me in the following choice bit:—"What Mr. Keith calls the electrolysis of gold is the electro-deposition of the *gold solution* (*sic*), &c." Oh, No! False spirit! I don't do that. Part of the electrolysis is the deposition of *gold from* the solution; and another part is the obtaining of gold *in* solution; both electrolytic operations as understood in the art. "Electricians ought not to speak loosely about electrical matters," Mr. Andreoli. Who ever heard of the electro-deposition of solutions before?

Of course, if I had meant my first sentence to be a definition of my title, it would read strange to our bogus Faraday with his peculiar understanding and use of our language. It was meant to be a broad statement about the present condition of the art; and I supplemented it by some facts about the "dissolving," "loosing," and "setting free" of gold from its matrices by means of electricity—electrolysis—and some about the subsequent "loosing or setting free" of gold, by means of electricity—electrolysis—from solutions containing it. Whether I said "very little or nothing on the electrolysis of gold solutions" I will leave the reader to judge.

I did write a lot of just such information as Mr. FitzGerald offers to your readers; but the committee of the Institution of Electrical Engineers asked me to cut it out, "because too elementary." That the president agreed with the committee is evident, because he stopped the further opening of Mr. F.'s "knowledge box," which was prepared so as to turn out a lot of information for students about a subject which he confesses himself "absolutely ignorant."

A friend at my elbow suggests that it might be well for me to consider my process well over again, for possible errors; because Mr. Andreoli commends it, though in a left-handed way.

I ask Mr. FitzGerald and the others to possess their souls in patience, and I may, in the near future, give in another paper to him and them information which they so hunger for, and which could not be given in a paper already so long that its reading took so much of the time they wanted in which to air their knowledge, or confessed lack thereof, about *the electrolysis of gold*.

N. S. Keith.

Gas v. Steam Engines.

I have perused the article published in the last number of the Electrical Review anent Gas *versus* Steam Engines. Allow me to say that your correspondent lost sight of the fact that if gas engines, as he contends, will still further improve, I will promise him that steam engines will not remain behind.

But I will principally answer to his manner of calculating consumption according to weight and price of coal burned.

Certainly gas engines may consume less *weight* of fuel than steam engines, but for gas engines, it is necessary to make use of dearer coal. The final expense will not show to the advantage of gas engines, as my calculations have proved, and it should be noted that in the calculation referred to I have not included any item for the wear and tear of the apparatus.

Concerning price of coal, I beg to assure my opponent that, in Belgium, poor gas cannot be obtained for less than 1 centime per cubic metre, whilst to get 1 kilo. of steam it will only cost 0·0011815 franc. Against this, the gas engine still requires 2 m³. 27 of poor gas at 0·01 franc, whilst the steam engine only wants 5 kilos. 46 of steam at 0·0011815 francs.

Now, concerning the outlay for steam plant of 330 H.P., I give below an estimate, and shall only be too happy if my opponent will do the same for a producer gas engine, and in this way the matter will be completely cleared up.

Let me also add that your correspondent says that 1 kilo. of coal will yield 4 to 5 cubic metres of gas with coal at 10½ francs per ton, and consequently producer gas costs ¼ to ⅕ of 1 centime.

I would be very pleased—and I dare say your readers would also—to hear of a producer gas plant producing gas at ¼ of 1 centime, but, let it be well understood, gas of which only 2 m³. 27 per H.P. would be required, whilst steam plants where steam can be got at $\frac{1}{10}$th centime per kilo. are not exceptional in Belgium, and certainly not in England, where coal is of a superior quality and cheaper in price.

In conclusion, in Belgium and the North of France, one steam engine horse-power costs, without maintenance and amortisation, * francs per hour.

Estimate of Outlay for 330 H.P. Steam Engine Plant.

Engine, compound condensing, H.P. 580 mm. × L.P. 900, stroke 1,200 mm., at 66 revolutions per minute...	45,000	francs.
Foundations	2,500	„
Piping	1,200	„
Two boilers of 70 square metres, Cornwall, Galloway	14,000	„
Foundation of boilers	3,400	„
Engine room buildings— 82 square metres, at 30 francs per square metre	2,460	„
Boiler room buildings— 100 square metres, at 20 francs per square metre	2,000	„
Chimney	2,000	„
	72,560	francs.
Carriage, packing, erecting, and sundries ...	3,000	„
Total	75,560	francs.

This is an estimate of outlay at the price of the very first class steam engine builders in our country, and for a perfect plant.

(*Ateliers de Construction, H. Bollinckx, Brussels.*)
For **L'Administrateur Délégué,**
J. Maillard.

P.S.—We will accept orders at above prices. We beg to send you per book post a report of trials made on our engines, which we consider as having a capital interest for all those concerned in steam engines.

* Our correspondent has omitted these figures.—Eds. Elec. Rev.

Superheating.

In your article on "Superheating" in the current number of the Review, there are doubts expressed as to the freedom from incrustation of the steam tubes over the fire in McPhail and Simpson's steam superheating apparatus. I, myself, had some misgivings on this very point, but after inspecting the tubes in two boilers after 3,500 hours' steaming, and finding merely a coating as thin as paint in them, I am perfectly satisfied on the point. I attribute this freedom from incrustation to the fact that the boxes which form the heaters to the tube act as most efficient superheaters. These boxes are kept clean by steam traps, which discharge regularly.

Wm. Hy. Patchell, A.M.I.C.E., M.I.E.E.,
Chief Engineer, The Charing Cross and Strand Electricity Supply Corporation, Limited.

THE DEATH BY ELECTRICAL SHOCK AT BRISTOL.

Major Cardew has presented the following report to the Railway Department of the Board of Trade with respect to the death of Robert Coleman, a Bristol Corporation official in one of the civic transforming rooms:—The system of supply adopted by the Corporation of Bristol is a high pressure alternating current supply to converting stations, from which a low pressure supply is given to consumers. The converting stations are, as a rule, established in cellars, to which the employés of the Corporation alone have access. Each station contains two transformers, which are enclosed in iron cases connected to earth, and a high tension terminal board. These terminal boards were intended to be used for the purpose of switching transformers in or out of circuit from the generating stations, by means of switches actuated through the "pilot" wires, which are separately insulated in the high pressure mains. This arrangement has, however, not yet been worked out, and I greatly doubt whether any such method would be found practicable. At present, the "terminal boards" are only used to carry high pressure fuses, and it has been found necessary to dust the arrangement occasionally, to prevent leakage. The unfortunate man was engaged in this operation, and the rule was, that he should do this with one hand only, and should wear an India-rubber glove on that hand, but he neglected his orders by holding the other end of the duster with his left hand, which was unprotected. While rubbing the charged metal with the duster he looked up, and was apparently about to speak to Mr. W. J. Wilcocks, another employé who was accompanying him, when the knuckles of his left hand touched the charged metal, and he uttered a loud cry, and then seems to have lost consciousness, but remained in a standing attitude, leaning slightly against the terminals, and, of course, with a powerful current passing through his body, until Mr. Wilcocks got behind him and pulled him off by his coat. Artificial respiration was tried, but without effect. The floor on which the man was standing at the time was of Portland cement and slightly damp, and no doubt the current passed to earth through his feet. The accident is due, in the first place, to great carelessness on the part of the man who was killed; but such carelessness on the part of uneducated men, when constantly dealing with electrically-charged metal, is very natural, and should be provided against by all possible safeguards. In this case, I cannot say that proper forethought had been shown. The metal terminals and fuses were so placed as to be easily touched, and the man was required to attend to their condition while they were charged. The only precaution adopted was a verbal order that only one hand, protected with an India-rubber glove, was to be used. Granting that the duty was one which was absolutely essential, much greater safety would be secured by providing that the man should wear India-rubber gloves on both hands, and India-rubber shoes, by making the floor of insulating material, such as asphalte, and by placing a guard of vulcanite round the exposed terminals. I cannot see, however, that the exposure of the high pressure terminals and fuses in this case is at all essential. It is a very common arrangement to enclose these within the iron casing of the transformer, and when so arranged, they can be left for months without examination. In this case the pressure would be switched off at the central station before sending a man to make an examination of the fuses and fittings within the casing. I strongly recommend that this arrangement should be carried out, at any rate until suitable apparatus has been provided. Another matter to which I drew the attention of the electrical engineer, and which I consider calls for remark, is the danger involved in the design and position of the high pressure fuses on the switchboard at the generating station, which are such as to make it inconvenient and even difficult to take out a fuse without touching metal charged to 2,000 volts. It may be necessary, and it is certainly convenient, to have exposed metal charged to high pressure on these switchboards, and the danger is to some extent reduced by the fact that the floor is of wood, and generally thoroughly dry, but the safety of the employés should be carefully considered in the design and position of the apparatus.

LEGAL.

Wise *v.* The Metropolitan Electric Supply Company, Limited.

This case came before Mr. Justice Stirling on 22nd inst. again, upon a motion for a writ of sequestration against the company for breach of an injunction restraining them from carrying on their business in such a way as to cause a nuisance to the plaintiffs by vibration. It will be remembered that the plaintiffs are lodging-house keepers residing in the neighbourhood of Manchester Street, and their case against the company is that the vibration caused by the electric lighting machinery is such as to constitute a serious nuisance and injury to them. The injunction was granted by his Lordship in April last, but its operation has from time to time been suspended in order to give the defendants the opportunity of abating the nuisance by means of alterations in their machinery and otherwise. The last occasion on which the case came before the Court was in November, 1894, when the company gave an undertaking not to use more than one reciprocating engine in addition to certain steam turbines which had been substituted for the original engines. The plaintiffs now alleged, and brought evidence to prove, that the nuisance still continued, and they pressed for the issue of a writ of sequestration.

Mr. Hastings, Q.C., and Mr. Beaumont appeared for the plaintiffs.

Mr. Waggett (who, with Mr. Vernon Smith, Q.C., appeared for the company), contended that this was not a case for the exercise of so extreme a remedy as the issue of a writ of sequestration. There was evidence that the nuisance was much abated, and that the vibration was now very slight, if it existed at all. If the plaintiffs were asking for an injunction on the present evidence, it would not be granted, and still less would the Court make an order of sequestration. The company had ordered two additional and improved turbines, which would be delivered in June, when the company would be able to dispense with the reciprocating engine altogether.

Mr. Justice Stirling said that the vibration was clearly much diminished, but it appeared to be still perceptible at times. He thought that when it did occur it was caused by the use of the reciprocating engine. There was no evidence before him that it was impossible for the company to carry on their work without the use of that engine, and instead of ordering a writ of sequestration to issue, he should put the company on terms not to use the reciprocating engine, and they must pay the costs of the motion.

BUSINESS NOTICES, &c.

Ready.—The Universal Electrical Directory. This directory for 1895, which is on sale at 22, Paternoster Row, by Messrs. H. Alabaster, Gatehouse & Co., contains a total of 20,958 distinct names of individuals and firms, being 2,500 more than were contained in the previous edition, and about 8,000 more than any other electrical directory published. In addition to the incorporation of new names, all have been carefully revised, much financial information has been added, the telegraphic addresses and local telephone numbers are given, and the total of pages in the work is increased by 80, making in all about 866 pages entirely of directory matter. Price 4s.

Acton.—Messrs. New & Mayne recently offered the council £500 for their electric lighting order on certain conditions. At the council's meeting last week the offer was accepted subject to the firm agreeing to the adoption of a sliding scale of prices if the council decided on that prior to signing the agreement.

Bangor.—The Water and Gas Committee on Monday discussed at great length the electric lighting question. It is stated that an elaborate report is shortly to be presented to the Council. Dr. Grey Edwards has sent a long letter to the *North Wales Chronicle* dealing with the question in detail.

Belfast.—The engineer's report to the Electricity Committee shows a continued improvement in the number of applications for current. The leading departments at the Post Office in Royal Avenue are among the latest customers.

Brighton.—On the 20th inst. a Local Government Board inquiry was held regarding the application of the Town Council for sanction to the borrowing of £48,100 for electric lighting extensions, and a sum for other purposes. The Town Clerk, in explaining the scheme, stated that already loans for £120,531 had been sanctioned. He gave the number of lamps in use as follows:—

1891.	1892.	1893.	1894.
5,706 ...	11,229 ...	17,760 ...	38,000

For 1894 the number includes 10,000 lamps taken over from the company. The following figures were given to show how the £48,100 will be expended:—

Cost of buildings	£13,449
Additional plant	£29,451
Street lighting	£5,200

In addition, £750 is required for purchasing a freehold house to be used for coal storage. The electrical engineer (Mr. Wright) explained that the new plant required will include six new 250 H.P. boilers to cost £3,600; economiser, £600; electrically driven feed pumps, £500; connecting pipe work, £1,800; condensers and pumps £2,500; two dynamos of the same type as the two purchased in 1894, £5,500; spare armature, £350; mains, £5,619; connecting new consumers, £4,000; difference in the cost of connecting up consumers in 1894 in

excess of the amount provided in the last loan, £1,455; connecting the circuits of the proposed 115 new arc lamps to the existing network, £1,000; coverings for steam pipes, &c., £494; contingencies, £1,900. Of the £5,200 for street lighting, £1,320 was the estimated cost of the new lamps, globes and switches. The lamp supports would cost £3,150, and the fixing £570. The amount required for connecting mains to lamps was £160. The Town Clerk requested that the loan be made repayable over a period of 40 years. In reply, the inspector (Col. J. T. Marsh) said the Local Government Board generally sanctioned loans for 20 years.

Bury.—A Local Government Board inquiry was held here last week into the Corporation's application to borrow £30,000 for electric lighting purposes. The Borough Surveyor said they would be able to supply 12,000 lamps and leave room for extensions. There would be three engines, three dynamos and accumulntors.

Cheltenham.—Baron de Ferrieres has undertaken to defray the cost of a 6 or 8-light electrolier for lighting the entrance hall at the public library.

Continental Telephones.—It is stated that an agreement has been signed between Holland and Belgium for the establishment of telephonic communication between the two countries. The first line between Brussels and the Hague will be opened on July 1st.

Dover.—This week test lighting has been made with the electric lamps from the Market Square to the top of Snargate Street, Dover.

Ealing.—The Electric Lighting Committee have reported that they have received several applications for the supply of arc lights. Mr. J. Sanders required 600 8-C.P. lamps for the Broadway establishment, and 50 for a new warehouse to be erected in Drayton Green Road. This made 4,755 8-C.P. lamps on the books, 3,456 of which had been connected, so they could not supply many more out of 5,000. Councillor Baker Hays said this would produce £1,728 per annum. Mr. Jones said no difficulty need be anticipated in that direction. With reference to the extension of the works the committee were of the unanimous opinion that the total liability should first be ascertained, and everything in hand cleared up before anything else were done. Mr. Baker Hays also addressed the council on the same subject, and the report was unanimously adopted.

Edinburgh.—Prof. Kennedy has submitted to the Electric Lighting Sub-committee a report on the extension of the high tension installation in the city, by running cables along Princes Street to Nicolson Street and Clerk Street, the Grange, and Morningside, so as to join the present system at the Barclay Church. The report also embraces the question of extending the light to the Royal and Regent Terraces and George Square, the probable cost being set down at about £4,000. It has been finally decided to turn on the electric light on April 10th.

Islington.—The Vestry has decided to engage temporarily an electrical canvasser. The salary is to be £3 per week and a commission of ½d. per 8 C.P. lamp for which orders are secured is to be paid.

Limerick.—The Gas Committee are awaiting a report from Prof. Alex. B. W. Kennedy, before taking further action in connection with the electric lighting project in Limerick. The gas works are the property of the Corporation, and in order to guard against any electric lighting company being established in the city, the Town Council obtained powers some years since to supply electric lighting if required. The period for which these powers were granted will expire within this year. Prof. Kennedy made a survey of the entire city over a month ago.

London.—We understand that the London County Council have refused to sanction the plans of the electric lighting company for the erection of an electric lighting station in City Road.

The clerk and surveyor of the St. Olave's Board of Works have met the solicitor of the County of London and Brush Provincial Electric Lighting Company, Limited, in conference before Sir T. W. B. Blomefield, of the Board of Trade, and agreed to certain amendments to the St. Olave's electric lighting provisional order in the interests of the parish.

Manchester.—The Corporation want to borrow £100,000 for electric lighting purposes. In the year 1892 and 1893 the Local Government Board's sanction was obtained to the raising of a loan of £150,000 for electric lighting purposes. The first idea was to put down a plant of a producing power equal to the adequate supply of 20,000 16-C.P. lamps. This, it was thought, would probably be sufficient for the first two or three years. The committee, however, deemed it wise to secure land and put building upon it large enough to enable them to double the plant if necessary. Accordingly they purchased land in the centre of the city at a cost of £44,779; put buildings (including offices) on the land at a cost of £24,075; the machinery, including boilers dynamos, &c., cost £35,566; the mains and cables in streets—in all about 61 miles in length—cost £48,505; electrical instruments cost £737; meters, £5,972; and the remuneration of the consulting engineer, Dr. John Hopkinson, was £4,250. The total was £163,886. This expenditure was £13,886 in excess of the borrowing powers, but it was an excess they had been unable to avoid. The committee found themselves at once overwhelmed with applicants, and their energies and efforts had been and were taxed to the utmost. In September, 1893, they had 82 customers consuming an energy equal to 4,000 16-C.P. lamps; in December the number of customers was 289, and the energy equal to 16,358 lamps; in March, 1894, 416 customers with 20,000 lamps, June, 1894, 450 customers with 21,542 lamps; September, 1894, 509 customers with 23,889 lamps; December, 1894, 624 customers with 30,149 lamps; February, 1895, 706 customers with 32,528 lamps. On the 12th of the present month the committee had 41 more applicants waiting to be connected, which when completed, would make a total of 747 customers consuming an energy equal to 34,528 16-C.P. lamps. At the end of the first year's working, after paying interest on mortgage, sinking fund, &c., and excess of management expenses—always proportionately greater on a first year's working—the committee found themselves with only a loss of £209 18s. 10d. That was from March 31st, 1893, to March 31st, 1894. From March, 1894, to March, 1895, they would be able to show a profit (after deducting interest and sinking fund) of some £7,000 or £8,000. Under these circumstances, he submitted, the committee were justified in their present application.

Newport.—The day load plant which was tested last week consists of a 50 H.P. semi-portable engine, which drives a direct coupled exciter. The output of the alternator is 12½ ampères at 2,000 volts. Shop lighting from the corporation mains commenced on Friday night last.

Nottingham.—The work of lighting St. Thomas's Church, Park Row, electrically, was completed satisfactorily last week. There are 125 lights in all, distributed as follows:—a corona of 24 lights in centre of nave, eight 4-light electroliers in arches, between naves and aisles, two 7-light standards light the choir, and one 5-light electrolier the altar. Besides this there are two 3-light brackets in chancel, and one 3 and two 5-light brackets immediately on entering the church, as well as lights on the pulpit, organ, &c., &c. The remainder of the lights are in the school rooms and vestries. The whole of the work has been done by Mr. Joseph Blackburn, of Nottingham. Other installations completed in this town by the same firm are St. Paul's Church, George Street, which is lighted with 87 incandescent lamps, as follows:—eight 4-light electroliers in nave, two 7-light pendants in choir stalls, and one 4-light pendant over altar, and thirteen 1-light pendants in the elevations, &c., &c.; Friar Lane Chapel, Friar Lane, and numerous factories, mills, workshops, private houses, &c., in the town. The lighting of the new Borough Club, in King Street, has also been placed in their hands—this is now nearing completion. Among the private house lighting contracts Mr. Blackburn has the lighting of Nettleworth Hall, near Mansfield, for the Rev. Fitzherbert.

Queenstown.—An electric lighting scheme is before the commissioners. It has been calculated that the cost of lighting the port by electricity would be about £360 per annum, and the cost of plant, including buildings, engines, dynamos, &c., about £600. The commissioners are to discuss the matter at their next meeting.

Shoreditch.—The Vestry seal has been affixed to the agreement appointing Mr. Manville, consulting engineer, in connection with the electric lighting and dust destructor schemes. The £12,000 required for the electric lighting scheme is to be borrowed from the County Council at 3¼ per cent. on the annuity principle, repayment to extend over a period of 54 years.

Southport.—Application is to be made to the Local Government Board for power to borrow £6,000 for arc lighting, and £12,000 for incandescent electric lighting. So far, borrowing powers to the extent of £28,000 have been obtained by the Council. It is not intended to apply all the new £18,000 to work at present, only about half of the sum allowed for incandescent lighting is really required, but it was considered advisable to apply for larger powers now to save the trouble of frequent applications to the Local Government Board.

Stafford.—The central station buildings will be completed within two or three weeks. The boilers and one engine are finished at the maker's works. The Town Council have adopted the Electric Lighting Committee's suggested regulations and conditions for wiring and fitting up consumer's premises, and the engineer has been authorised to purchase fittings.

Stockton.—It is proposed to introduce the electric light into the Theatre Royal at Stockton.

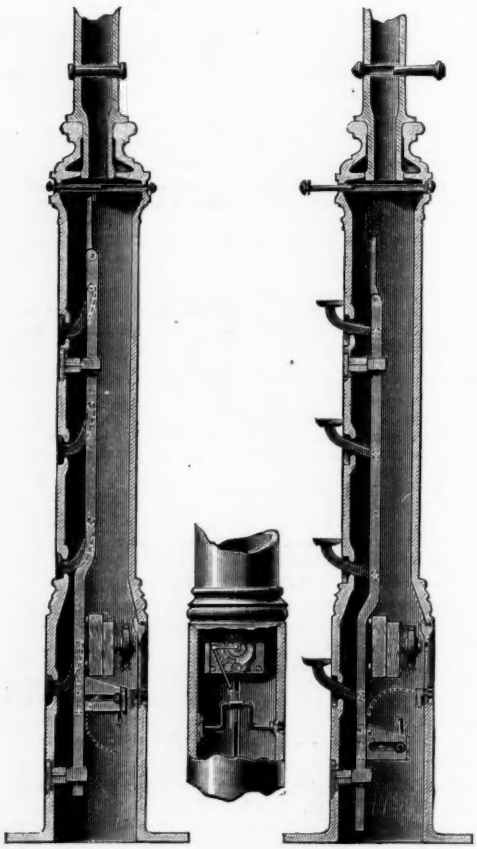
Weymouth.—The Note which appeared on page 323 under the heading "Dorchester," should read as Weymouth, at which town Mr. Vincent's installation was fitted up, the contractors for the work being Messrs. Royce & Co., Limited, of Manchester.

Whitechapel.—The District Board of Works discussed the whole electric lighting question and the proposed scheme on Monday last. The discussion was adjourned.

Bankruptcy Proceedings.—A first meeting in *re* G. F. Rogers was held on Monday. The debtor, a telegraph engineer and general merchant, of Great Winchester Street, furnished accounts showing liabilities £27,982 (£19,800 expected to rank), and assets £264. He has also acted as director of public companies, and attributes his failure to liability on accommodation bills, for which he received no consideration, to loss in trading and investments, and depreciation in value of securities held by creditors. A trustee and committee of inspection were appointed to wind up the estate in bankruptcy.

Business Announcement.—Mr. T. G. Poole has taken offices at No. 11, Queen Victoria Street, so that in future all business communications should be made there.

A Safety Arc Lamp Standard. — The Falkirk Iron Company are manufacturing a special form of arc lamp standard which possesses considerable merit. It practically combines a ladder climbing arrangement with switching gear. The idea, as will be gathered from the illustrations, is that at such times when the current is on the post cannot be climbed, and when the top is accessible the current is off and the lamp out. Each post has its own self-contained climbing gear—a series of foot-rests which simultaneously project or withdraw by turning a key at the base of the column. Such an arrangement obviates the necessity of carrying about a ladder from place to place, and may even dispense with the services of an assistant. The lamp trimmer carries with him a small key which renders every lamp accessible, while it is quite unclimbable by other persons. The accompanying illustrations show the patent ladder applied to the lower portion of the post, and loose foot-rests fitted in cross tubes of steel in the upper part, where they are out of reach from the ground. This plan, we understand, is the most economical in first cost, and it is perfectly satisfactory in operation. The controlled ladder may, however, be fitted all the way up when desired. A crank at the base, one end of which can be reached by a



key through a small hole, controls a vertical rod, as shown. This rod has a series of steps jointed to it of such a form as to facilitate their motion through slots in the wall of the post. When the crank is turned half a revolution, the controlling rod is lowered and the steps project from the side sufficiently far to form a perfectly safe and easy means of climbing. As the tread closes up against the post it keeps dirt and wet from getting inside the column, where their presence would have a deleterious effect on the insulation of the electrical conductors. The draw-out pegs or foot-rests shown in the narrow part of the pillar are fitted in guide tubes so as to be quite watertight, and at the same time to ensure facile working and entire freedom from liability to jam. By the novel use of a hollow ornamental head or rosette, the steps can always be made of such a length as to give an ample foothold; even in pillars no wider than 4½ inches at the top. The switching arrangement by which the current is cut off as the steps are shot out is not shown, because it is obvious that there are many ways of accomplishing this. The makers claim that the cost of the arc lamp column is very little enhanced by such an arrangement. We feel sure that if such is the case, the merits of this novel lamp-post will be most carefully considered by those using arc lamp standards.

Change of Name of Firm.—The business hitherto carried on in Bradford as the "Wray Electrical Engineering Company," will, on and after April 1st, be known as the "Phœnix Dynamo Manufacturing Company." Mr. Rankin Kennedy, the well-known electrical engineer, has been engaged as manager, and large and well equipped new works are being fitted out at Hubert Street, Leeds Road, Bradford, where dynamos, motors and alternators of the largest types will be manufactured. Rankin Kennedy's single bobbin dynamos, alternators and commutatorless motors will be specialities of the new business. Already two 40-H.P. motors for 500 volts pressure are in hand to the order of The Ackton Hall Colliery Proprietors, Featherstone, one for underground haulage, and the other for driving a coal screening machine.

Dissolution of Partnership.—The partnership heretofore existing between S. M. S. Turner and R. M. Trille, known as Turner and Trille of the Marathon Works, Don Street, St. Helier, in the Island of Jersey, Electrical and Mechanical Engineers, has been dissolved by mutual consent. The assets and liabilities of the said business, together with the goodwill thereof, were taken over by the said S. M. S. Turner.

Electric Pumping Machinery.—We are informed that the Lothian Coal Company, Newbattle Collieries, Dalkeith, N.B., have placed an order with Messrs. Ernest Scott & Mountain, Limited, for another large set of pumping machinery. About two years since the same firm placed a contract with Messrs. Scott & Mountain for two sets of pumping machinery, each set to deliver 200 gallons per minute against a head of about 700 feet, the plant consisting of two horizontal engines of 120 effective H.P. each, with dynamos, motors, and three-throw ram pumps of their improved design. This plant has given such satisfaction, and has proved so economical in working, that the firm have now placed the present order with Messrs. Scott and Mountain, so that the plant, when completed, will be capable of delivering 600 gallons per minute against a head of 700 feet, but, in case of emergency, could be considerably pressed. Messrs. Scott and Mountain have also an order in hand for an extension to the electric pumping plant which they supplied to the Cambois Colliery, Northumberland, and are supplying a dynamo and electric motor, with gearing complete, for driving a pump which has hitherto been driven by wire ropes, at Newton Colliery, Felton, Northumberland. We understand that the firm are busy in their engineering department, having orders in hand for the pumping machinery for H.M.S. *Mars*, and also for H.M.S. *Venus* and *Diana*, and have recently completed for their agents in India two sets of stern wheel machinery, and are in receipt of a third order for compound stern wheel engines and boilers.

Isle of Man Tramways.—The Douglas Town Commissioners the other day discussed the question of a tramway service for Upper Douglas. Pending the result of an interview with the directors of the Electric Tramway Company, it was suggested to engage an engineer to report upon a cable system for the district. Finally, however, the discussion was adjourned.

Llandudno Electric Tramways.—The residents in the districts through which the proposed electric railways are to run are being canvassed as to their opinions for and against the scheme, of which we understand the Manchester Edison & Swan Company are the promoters.

Mavor & Coulson.—Mr. Carrington Smythe, of 12, Idol Lane, E.C., has been appointed sole agent for London and district for Messrs. Mavor & Coulson, engineers and electricians, Glasgow, and will represent them for the sale of their manufactures, including Sayers's patent dynamos and motors, "C C" concentric system, also for equipment of complete lighting and power installation, electric traction, heating and welding, and electric launches.

New Zealand Electrical Syndicate.—On behalf of first mortgage debenture holders in this syndicate, Mr. Justice North was asked last Friday to appoint a receiver and manager, with power to borrow £2,000, for paying off pressing claims, &c., and for the purpose of keeping the business going. Mr. Stewart Smith, for the company, was willing to submit to an order. After hearing arguments and affidavits, his Lordship appointed the principal plaintiff, Mr. Barcley, *ad interim* receiver. Subsequently Mr. Justice Kekewich, on being applied to, granted leave to other parties interested in the company to serve short notice of motion for Tuesday next, to compel registration of a transfer of shares, and for an injunction restraining the previous applicants to Mr. Justice North from acting as directors of the company.

Personal.—Mr. T. A. Nunwick, formerly branch manager and representative in the North for Messrs. Poole & White, Limited, has now joined the firm of Messrs. Dorman & Smith as their representative for the Northern and Midland Counties.

Price List.—We have received from Messrs. Holden and Brooke, Limited, a copy of their abridged catalogue of "Injectors and special steam appliances." The list is illustrated and priced.

The City Electric Athletic Club.—This club, which is in connection with the City of London Electric Lighting Company, gave their third annual Bohemian Concert at St. James's Hall, on Tuesday evening last. Sir David Salomons presided over a very large audience, which seemed to thoroughly enjoy the musical fare provided.

The Epstein Electric Accumulator Company, Limited.—The secretary of the above company is sending out a circular to the effect that it has come to the knowledge of the company that plates are being offered by other makers of accumulators which are essentially Epstein plates. Users are cautioned against employing plates which are made by infringing patents owned by this company. Opinions in support of the validity of the Letters Patent have been given by Sir Richard Webster, Q.C., M.P., Sir Horace Davey, Q.C. (Lord Davey), Mr. Fletcher Moulton, Q.C., M.P., Mr. Aston, Q.C., Mr. R. W. Wallace. The company's solicitors have been instructed to take proceedings against all companies and persons using such plates.

U.S. Electrical Manufacturing Companies.—A *Times* despatch from Philadelphia says that to prevent ruinous prices, arrangements are nearly completed for "pooling" the Westinghouse, Edison, and other great electrical companies.

CONTRACTS OPEN AND CLOSED.

OPEN.

France.—The General Direction of the French Posts and Telegraphs in Paris is inviting tenders, until April 5th, for the supply of eight lots of Baudot telegraphic apparatus.

Germany.—April 17th. The German Public Works Authorities (No. 1 Nord) at Königsburg, are inviting tenders for the supply and erection of six pumping engines, to be operated by steam or electricity.

Leicester.—The Gas and Electric Lighting Committee of the Leicester Corporation are prepared to receive tenders for the supply of about 6,000 yards of high and low tension cables. Specifications and form of tender to be obtained upon application to the engineer, Mr. Alfred Colson, M.Inst.C.E. Further information may be obtained from our advertisement columns.

Rangoon.—November 4th. The President of the Rangoon Municipal Committee invites tenders for the lighting of Rangoon by electricity. All information regarding the existing system of lighting and the cost, &c., with plan of the town, can be obtained on application to Messrs. Ogilvy, Gillanders & Co., Sun Court, 67, Cornhill, London, E.C., accompanied by a remittance of one guinea.

CLOSED.

Southport.—The following tenders have been accepted for additions to engine and boiler house, electricity works, Crowlands, for the Corporation:—Section 1—H. Connard, Southport, brickwork, &c., £564. Section 2—J. Blanchard & Sons, Southport, joinery, &c., £541. Section 3—E. Wood, Manchester, ironwork, £669.

Stafford.—The Town Council has accepted the tender of the Electric Construction Company for a switchboard, also that of Messrs. C. & W. Walker for an overhead tank, to contain 12,000 gallons, at a cost of £117.

NOTES.

Chester Electric Lighting Matters.—Over three years ago a movement was made at Chester to consider the question of electric lighting for the town; to-day, however, through the continuous persistency of curious circumstances, it would seem that there is less likelihood of the Council running its own installation than ever. Dr. Hopkinson, during the past year or two, has been advising the Council and drawing up specifications. The last scheme and specification he drew up were adopted by the Electric Lighting Committee, and being so adopted, it would be but natural to expect the members of such committee to stand by their decision to the last. Not so at Chester, however. The Electric Lighting Committee's recommendations came before the whole Council some days ago for final adoption, and then it was that more than one responsible member of the committee took a stand entirely opposed to the course resolved upon in committee. This turn in matters ended in the suggested scheme being rejected by 21 votes to 9. The following incident that occurred during the discussion will convey an idea of what class of men the Chester Council is composed. Dr. Hopkinson estimated the cost of a certain scheme at a stated sum (£25,000, we believe); a councillor privately consulted "an engineer," and at that meeting stated that, having done so, he was in a position to know that Dr. Hopkinson's scheme could not be carried out for less than double the sum estimated. He did not state the name of the said "engineer," but, whoever he may be, we should stand by Dr. Hopkinson's figures, for who is more capable of calculating to a nicety what the exact cost would be? In view of these facts, and having watched affairs at Chester for some time past, we are not altogether surprised to learn from a local source that Dr. Hopkinson has expressed to the Town Clerk his desire to withdraw altogether. This leaves three courses now open to Chester to help them out of the difficulty: (1) Councillors to forego their undignified methods of conducting the business, and place just confidence in a newly-appointed adviser, and any statements he may make; (2) To continue their present undignified methods, and secure a consulting engineer who will submit to being a mere puppet in their hands, having no mind of his own, or if he has a mind, to allow his opinions and recommendations being over-ruled; and (3) to abandon the electric lighting scheme as a municipal undertaking, and let a private company take it in hand and carry off the profits. The latter will be a very humiliating procedure now that a nice little sum has been expended upon professional advice, but it might turn out best in the end.

Town Refuse for Steam Raising.—In *Cassier's Magazine* Mr. I. W. Baker has been riding his hobby of town refuse disposal, but we are glad to see that he talks of an evaporative duty of 1 lb. of water per pound of refuse, or 2½ per pound of sifted material (breeze). He describes several types of destructor, but would himself place the steam generator directly over the furnace, so as to get the advantage of direct heat, while he would place other furnaces above the refuse furnace to act as cremators. It is not very clear what Mr. Baker means when he refers to the absorption of heat by the brickwork of flues, and hence the necessity of absorbing it directly by the generator. The descriptions are too general for clear abstraction, but we are much inclined to think that the author is, if not on the wrong tack, at least far too much given over to the fetish of steam raising from the combustion of rubbish. There is a mischievous impression abroad that wet rubbish, because it contains large amounts of valuable half-burned coal, is necessarily of high value as fuel, and the designers of refuse destructors pay court to this error in attempting too much, and the result is imperfect destruction. For the continuous working of a destructor plant and the utilisation of the heat generated, Mr. Baker proposes to have a tank roof to the boiler house, and to turn into this all the steam produced in the daytime, and then at night, when electric lighting used up a large amount of power, he would use this boiled (and therefore non-incrustation forming) water as feed water to the boilers. Now, Mr. Baker shows an ordinary rectangular tank unstayed, and evidently only intended for a simple tank. Yet he speaks of heating up the water in this to 300° F., an obvious impossibility. In the face of a statement like this, it is impossible to regard Mr. Baker as a safe guide on a question of evaporation or heat utilisation. The whole atmosphere of refuse destruction seems to be disorganised. Such rash and unconsidered statements are made, such absurd claims put forward, and such enormous sums asked for so-called patents, that every cautious man is now on his guard, and looks suspiciously on every claim advanced. Now, 300° F., in an open tank, will call for a lot of explanation. Better stick to 200°.

A New Use for Aluminium.—A communication to the Liège section of the Association des Ingènieurs de Liège, by Mons. J. Faucan, engineer at the Ateliers de la Meuse, on the refining of metals by means of aluminium, terminates with some suggestive remarks relating to the use of this new metal in metallurgical operations. The adoption of aluminium as a refining agent involves the suppression of the use of silico-carbonated iron, and a diminution in that of ferro-manganese, aluminium playing the same part as the former under better conditions, and restricting that of the latter to the elimination of sulphur. In the metallurgy of nickel steel great homogenity is secured; in making iron and steel castings, to say nothing of red shear iron, aluminium plays an important ameliorating part, the castings are clean, very compact, and stand as well either hot or cold; in dense brass castings aluminium produces an effect which is very marked, rendering them easy to work, and having an electric conductivity more than double that of ordinary castings. There are other advantages which cannot here be referred to, but they are all classified under the two general categories of convenience and economy.

London County Council and the Telephone.—The County Council has decided to spend £100, if necessary, in placing the Council's views before the Select Committee of the House of Commons on the telephone service. We consider this £100 will be absolutely wasted. The only end to be gained by the Council will be to further reveal its ignorance regarding the subject.

The Responsibilities of Submarine Cable Companies.—The action brought by the Direct Spanish Telegraph Company, Limited, against the owners of the ss. *Caloric*, which was decided, as we mentioned last week, in favour of the defendants, is one which should not be allowed to pass without affording a lesson to owners of submarine telegraph cables. The whole point seems to have been that the defendants were not aware that there were any telegraph cables near the position in which the *Caloric* came to anchor. None were shown on the charts, and no mention was made of any in the book of directions which was on board. It has often seemed to us that owners of such valuable property as telegraph cables scarcely take sufficient trouble to let their whereabouts be generally known; there seems to be a feeling that the less published information there is the better. We believe that the Hydrographer of the Admiralty would be only too ready to plot all shore ends on his charts—in some cases he has already done so. Such published information might often save cables from damage and could not possibly be of any disadvantage to their owners. Apart from the legal side of the case, there can be no doubt that the captain of the *Caloric* showed great want of thought in not freeing his anchor before the cable was chafed through. Finding his single anchor, with 75 fathoms of chain attached, dragging, and having no standing tackle to get his second anchor out (!) he determined to shift his position and started heaving in. On sighting the anchor he found two cables on it, and instead of trying to pass a rope under them and clear his anchor, the carpenter was sent over the bows to try and cut them adrift, the ship all the time riding by the cables in a gale of wind, though, we presume, smooth water, the captain being afraid, as he stated, to move his engines for fear of the propeller fouling the cables which were across the anchor. And yet we were once told that any boatswain can lay a cable! One notable instance of a company which is large minded enough to publish information about their cables is to be found in the case of the India-rubber, Gutta Percha and Telegraph Works Company, which has presented to the libraries of both the Institution of Civil Engineers and the Institution of Electrical Engineers the full diaries of all the recent cable operations carried out by their ships; and this information is the more valuable since it is genuine and unvarnished.

Interruptions and Repairs:—

Line or section.	Interrupted.	Restored.
Cable—Cadiz-Teneriffe	26/12/94	13/2/95
„ Pernambuco-Ceara ...	12/1/95	5/2/95
„ Gibraltar-Tangier	14/1/95	30/1/95
„ Gibraltar-Cadiz	14/1/95	12/2/95
„ San Thomé-Loanda ...	22/1/95	9/2/95
Line—Saigon-Bangkok	29/1/95	3/2/95
„ „ „	28/2/95	1/3/95
„ „ „	6/3/95	6/3/95
„ „ „	14/3/95	14/3/95
„ „ „	21/3/95	26/3/95
„ San Juan del Sur-Punta Arenas	6/2/95	10/2/95
Cable—Para-Maranham	9/2/95	18/2/95
Line—Moulmein-Bangkok ...	9/2/95	14/2/95
„ „ „	19/2/95	21/2/95
„ „ „	5/3/95	9/3/95
Cable—Constantinople-Odessa ...	20/2/95	21/2/95
„ „ „ ...	25/2/95	12/3/95
„ Alexandria-Port Said ...	2/3/95	14/3/95
„ Campeche-Yucatan ...	23/3/95	25/3/95
„ Martinique-Paramaribo ...	20/2/95	21/3/95

Lines and Cables Still Interrupted.

Line or cable.	Interrupted.
Cable—Brest-St. Pierre (Anglo-American Company)	6/4/93
„ Latakia-Cyprus	27/11/94
„ Hong Kong-Macao	31/12/94
„ Cadiz-Teneriffe	22/2/95
„ St. Louis-Fernando de Noronha	12/3/95

Alternating v. Direct Currents.—Mr. Dawbarn, at the commencement of his paper on page 401, states that the great duel—alternating *versus* direct currents—was fought to the bitter end, and one of them is dead. No doubt there are a number of people who will be glad to know which?

The Madagascar Cable.—The *François Arago* is reported as having arrived at Mozambique, after a rapid passage, on the 19th inst. There is therefore some possibility that the cable to Majunga will be laid by April 1st, the contract date. Some information as to the terms of contract between the French Government and the firms, Grammont & Son, and the Société Industrielle des Telephones, has now been published. Offers were made by English firms to lay the cable, which is 405 miles long, for 1,250,000 francs (say £50,000), within 65 days from the date of the signing of the contract; but patriotism demanded that the work should be done by Frenchmen only, and the price of 2,100,000 francs (£84,000) was therefore agreed to. The core is composed of copper and gutta-percha, weighing each 130 lbs. per mile. The C.R. is not to exceed 10 ohms per mile, and the G.P.R. is to be between 300 and 2,500 megohms per mile, after 2 minutes' electrification, with a battery of 200 Daniell cells; both tests to be made at a temperature of 75° F. The electrostatic capacity must not be more than 0·400 of a microfarad per mile. The core for the shore end type is to be protected against teredo by the usual brass tape. The deep sea type is sheathed with 16 wires, each 0·975 of an inch in diameter, and having a breaking strain of at least 924 lbs. each (70 tons per square inch). The intermediate type is sheathed with 10 wires, each 0·195 of an inch in diameter. The shore end type is composed of the deep sea type, re-sheathed with 11 wires, each of 0·264-inch diameter. Strange to say there is no mention of quality of wire in these two last types, beyond the specifying of a minimum breaking strain. The penalty for each day after April 1st, during which the cable is uncompleted, is £200 for the first 15 days, and £400 per day after that period. The landlines connecting the stations with the huts are to be composed of the ordinary deep sea type of cable.

We learn that considerable difficulty has been experienced at Toulon in shipping some 13 nautical miles of cable on board the ss. *Bugalet*. This cable is intended for Madagascar. The operation of shipment is described in the French papers as "very slow, and above everything very difficult."

The Interruption of Australian Landlines.—From Australian papers recently to hand, we learn that the locality of the interruption on the South Australian landlines was between Charlotte Waters and Alice Springs. These places are in the interior, about midway between Adelaide and Port Darwin. The delay to traffic between Australia and Europe caused by this breakdown was in one case about one day, and on the last occasion about six days. The Roebuck Bay route was not available, as the landline to the north of Perth (Western Australia) was also interrupted on both occasions, and consequently useless for the transit of international telegrams. In alluding to this vexatious interruption of traffic, the Sydney *Morning Herald* says:—"Whatever the cause of it, the sudden silence of the whole service, with its duplicate wires and triplicate cables, will accentuate the demand that the Colonies should have an alternative service under totally different conditions, such as can only be supplied by the Pacific route."

Telegraph Rates to the East.—The Secretary of State for India has been informed by telegram that the junction of the Chinese and Burmese landlines was effected on March 16th. This result was due to the successful efforts made by the Telegraph Department to effect connection as quickly as possible, and to the promptitude with which the Chinese officers have responded to those efforts. It is to be hoped that this new means of communication with China will have its effect in reducing the rates. The present rate to China, *viâ* the Eastern Extension Telegraph Company's cables, is 7s. per word, while the rate to Burmah is only 4s. 2d. per word. The Burmese and Chinese system of landlines being now united, should afford a less expensive means of communication with the latter country.

A Good Year at Manchester.—From a statement made the other day by the chairman of the Manchester Gas Committee, it appears that for the year ending March, 1895, the electric light undertaking shows a profit of some £7,000 or £8,000; this is after deducting interest and sinking fund. It was also stated by another speaker that this year the price is to be reduced from 8d. per unit to 6d. We shall await further details with great interest.

Selection of Motive Power.—Continuing his article in the *Engineering Magazine*, Dr. Emery gives a table showing the cost of a horse-power for different types of engine suitable for the amount of power required, and on a basis of coal cost of 12s. 6d. per ton. The estimate includes fuel, labour, supplies and repairs, and taxes, and an additional 5 per cent. and 10 per cent. for interest. The total cost for a year of 3,080 hours is thus found as per table below :—

Class of Engine.	Net horse-power.	Cost per year at			Evaporation per lb. of coal.
		5 per cent.	10 per cent.	Water per H.P. hour.	
Ordinary high-pressure engine...	10	£15·10	15·66	42	7·5
Cut-off high-pressure engine ...	75	£8·19	8·81	28	8·25
Cut-off condensing engine	150	£6·22	6·84	22	8·50
Compounding do.	250	£5·04	5·68	18	8·50
Triple ditto ...	500	£4·28	5·01	19	8·50

The figures employed by Dr. Emery appear to be reasonable, and not simply test figures, and the results afford him a base of criticism of water-power. Thus taking the utilisation of the Merrimack River, the cost of development had been £15·4 per horse-power, and the cost of flumes, wheels and tail races, came to about £13 per horse-power utilised. The total is £28·4, to which, adding 2½ per cent. for depreciation, and 1½ per cent. for repairs, and the same for taxes, and 10 per cent. for interest and dividends, as in the steam table above, we get a total annual charge of 17 per cent., or £4·83, which is nearly equal to the cost of the most economical engines, and as there is a use very often for exhaust steam for heating purposes, a steam generated motive power may easily compete with water-power, and we should think this is specially emphasised where steam-power must be used as a stand-by, so as to avoid the stoppage due to frost. But so many conditions come in, that every case requires its own special consideration. The remainder of Dr. Emery's paper is merely discussive and conversational, and electrical transmission is barely touched upon.

A New Point in Electro-Metallurgy.—At the usual meeting of the Paris Academy of Science on January 28th, a paper was read by Mons. Jules Garnier on the action of the electric current upon a series of metallic sulphides whilst in a state of fusion. Having in a previous research (*Comptes Rendus*, June 19th, 1893) established that carbon at a red heat, under the influence of an electric current of low voltage, is transported from the positive to the negative electrode, thus indicating the possibility of a new "cementation process" for iron, he thought that this action of the current ought not to be limited to iron. Hence he has examined the behaviour of the current towards metallic sulphides whilst in a molten condition. The results of the experiments undertaken to investigate this matter lead to the following conclusions: Sulphur combined with the metals in a fused state out of contact with the air, and traversed by an electric current, the electrodes being carbon (at least the anode being of carbon), is gradually eliminated, forming sulphide of carbon. In the fused mixture under the above conditions, the electrical conductivity of the mixture increases little by little as the sulphur is slowly eliminated. It is possible that the results, so closely connected as they are with results from which Mons. Garnier deduced a commercial electrical process for the cementation of iron, may have a strong bearing upon the future developments of electro-metallurgy—at least upon that portion of it which deals with the treatment of ores, many of which are sulphides.

Lectures.—Before the Ford M.I. Association at Plymouth, last week, Mr. W. H. Roberts read a paper on "The Laying of the Atlantic Cable in 1866."

Early this month a lecture on "Electric Lighting in Bombay" was delivered at the Sassoon Mechanics' Institute by Dr. H. H. Tavaria, B.Sc.

Before the members of the Edinburgh Section of the Incorporated Society of Musicians, Mr. Hope-Jones lectured on "Science as Applied to Organs," on Saturday last. Why not have said "the Hope-Jones electric organ"?

Mirrors of Magnetism.—Our knowledge of electric images is based almost entirely upon mathematical deduction. It would be difficult to demonstrate satisfactorily their properties by experiment. We are content therefore to take the elegant geometrical proofs that Lord Kelvin has given us, and to corroborate them physically when the conclusions are within reach of experiment. Hence the subject is one of purely theoretical interest, but so beautifully does it elucidate difficult problems in electrostatics that it remains the continual delight of text-book writers. Magnetic images, on the other hand, are entirely neglected, and yet these are much more likely to be practically utilised in the near future than their electrical analogues: it may be in questions of dynamo and instrument shielding, or it may even be in the solution of that commercial problem, the testing of the magnetic properties of iron *en masse*. The existence of magnetic images is suggested by considerations altogether apart from the mathematical. If a solenoid of wire through which a current is flowing be taken and its end placed against a large plate of iron, we eliminate the effect of that end upon the distribution of the field about the coil, and so obtain a field on one side of the plate of a shape the same as if the coil were continued to double its length. If we place the coil with its end against a mirror we see it reflected in the mirror so that it appears to be double its real length. Thus the iron plate gives us magnetically an image of the coil analogous to the optical image produced by the mirror, geometrically identical with the optical image, virtual and erect. If a large iron plate is placed at each end of the coil the field will be the same as if the coil were infinitely long; and we know that two mirrors, facing each other, one at each end of the coil, would give it the appearance of stretching away to infinity in both directions. Such effects could only be obtained if the mirror were a perfect reflector and infinitely large, and similarly the magnetic effects could only be perfectly obtained if the plates were perfectly permeable and infinitely large. The subject is extremely interesting and full of possibilities of an order calculated to enlighten us upon many points of difficulty in commercial practice. Hence we are glad to see that Prof. Silvanus P. Thompson and Mr. Miles Walker have been devoting some attention to it. A paper by them on some of their investigations appears in the February issue of the *Philosophical Magazine*, and will be found extremely interesting by those of our readers who care to look it up.

Bury and its Electrical Engineer.—Whatever we may think about the stipulations connected with the appointment of an electrical engineer at Cardiff, Bury might well have taken a leaf out of its book. Cardiff made up its mind as to the status of its newly-appointed man before advertising for him, but the Bury Corporation, when they engaged Mr. W. R. Wynne as their electrical engineer, left certain points far from clear. He was engaged under the fog of vague advertisements, and after he commenced his duties the question arose as to whether he was to work on an equal footing with the borough engineer, or under him. The Corporation, after considering the matter, decided to carry on the work without Mr. Wynne's assistance. In other words, they discharged him. The week before last Mr. Wynne's action against the Corporation for wrongful dismissal was heard at Liverpool. A verdict was given by consent for the plaintiff, and it was clearly stated that when he was dismissed there was no suggestion against his competency as a professional man, or his character as a gentleman. We trust that Mr. Wynne will soon be at work again under more congenial surroundings, for, so far as we have been able to judge from correspondence which has come to our notice, and from the reports of the legal proceedings, it seems that he was most unfairly treated.

Some Electrolytic Separations.—Mr. Edgar F. Smith continues to prosecute his researches on the electrolytic separation of the metals, and in this way to supplement the classical generalisations of Classen. In the *Journal* of the American Chemical Society, xvi., p. 420, he has a paper on the separation of silver from copper, mercury from copper, and silver from cadmium. In this paper he gives some data of actual experiments, and shows how his methods work in practice. We commend it to all who are studying this subject, as being worthy of careful perusal.

Prof. Ramsay's Alleged Discovery of Helium.—At the annual meeting of the Chemical Society on Wednesday, the discovery of a new element was announced by Prof. Ramsay. He is reported to have said that he had examined the gas given off by the mineral clevite when treated with sulphuric acid, and discovered that it was argon, and not nitrogen, as had been hitherto supposed, and in a telegram to Berthelot he states that helium is contained in it. Spectroscopic examination showed a very bright yellow line nearly coincident with the yellow sodium line. This line was found to be identical in position with the yellow line observed in the spectrum of the sun's chromosphere, and attributed to the hypothetical element helium. Whether helium could be separated from argon remained to be seen. Helium is said to be so named in order to account for a special line in the solar spectrum, which line many scientists claim to have noticed in the spectrum of the aurora borealis. M. Berthelot added that from observations made by himself in the course of experiments with argon, the spectrum he obtained from the shower of sparks in the test tube was a very remarkable one from its analogy to the spectrum of the aurora borealis, and we have yet to see what part the use of electric sparks has played in these discoveries. Prof. Crookes gave some additional particulars of the spectrum of the gas from clevite. He found certain coincidences with the band spectrum of nitrogen, particularly in the ultra violet region, but some lines were present which were not found in the nitrogen spectrum, and *vice versa*. The discovery, of which it is said there is no doubt, was only made a few days ago. Assuming that helium has been found, it will strike everyone as curious that the discovery is announced as one of a few days ago. At Oxford, in August last, Rayleigh and Ramsay announced the discovery of argon, and it was spectroscopically examined by Prof. Crookes. By another process Prof. Ramsay, the other day, obtained argon, and mixed with this latter sample, he is reported to have found what appeared to be another gas, and again it was submitted to Prof. Crookes. We suppose that argon is argon all the world over, and the puzzle is how Prof. Ramsay missed finding the other gas, and Prof. Crookes overlooked the "very bright yellow line" in the older argon, which had been subjected to every test the distinguished discoverers could devise for the past eight or nine months. Their inability to make argon enter into combination, when Berthelot succeeded in his initial effort, forms the subject of comment in our leading columns.

Berthelot's Experiments on Argon.—The products of argon when made to enter into combination with benzene vapour appear to be similar in character to the products obtained with *nitrogen* and benzene. A yellow, resinous, odorous substance, condensed on the surface of the two glass tubes; this substance decomposed on heating, yielding an abundant carbonaceous residue and volatile products, which reddened litmus paper.

McPhail & Simpson Superheater.—Regarding what has been said in another column as to the McPhail & Simpson superheater, we would desire it specially to be understood that we do not, therefore, approve the very large demand now being made upon the public for the sale of the patent and business, viz., £416,000. No superheater can be worth this, for there are other ways of superheating than the one in question; and however good may be the results obtained, they are neither unexpected, or such as have not, and may not, be obtained by other apparatus. Admitting the excellence of the apparatus, we do but admit what inquiry has led us to believe, and, unlike sundry other things—certain furnaces or smoke-washers—there is genuine value in this new superheater, just as there is in a modern 30 × 8 steam boiler, but no one is going to pay £20,000 for a plain Lancashire boiler, and the public, we trust, will not pay £416,000 for a superheater patent.

Reduction in Price per Unit.—The Chelsea Electricity Supply Company, Limited, announces that on and after July 1st, 1895, current will be supplied at the following prices:—For lighting purposes, 6d. per Board of Trade unit, with a sliding scale to 5d.; for motors, cooking, and heating (by separate meter), 4d. per Board of Trade unit.

Deep Sea Soundings.—The annual list of oceanic depths and serial temperature observations received at the Admiralty during the year 1894 has recently been published. The total number of soundings is 342, and of these only some 93 have been taken by telegraph steamers; the remainder are by H.M. surveying ships and those of the Indian Marine. In addition to sounding work, H.M.S. *Penguin*, *Waterwitch*, *Egeria*, and H.M.I. M.S. *Investigator* carried out some interesting serial temperature observations, which cannot fail to attract those interested in submarine research. One of the spots worked at was identical with a previous station of the *Challenger*, and also of the *Buccaneer*.

High Voltage Lamps.—The cement works of Messrs. I. C. Johnson & Co., Limited, at Greenhithe, Kent, are being lighted with arc and incandescent lamps. An interesting feature is the adoption of 200 volts as a common pressure for both arc and incandescent circuits. The 200-volt incandescent lamps are of English make. The area of lighting is somewhat extensive, the firm's quarries and wharves being situated at a considerable distance from the works proper. We understand that the work has been carried out by Messrs. Croggon & Co., Mr. J. A. Colquhoun being the engineer in charge of the erection.

The Cross Channel Cables.—By an arrangement made between the French and English Postal Telegraph Administrations, the maintenance and repair of three of the six cross-Channel cables landing on French soil will be taken over by the French Administration on April 1st. All these cables have been maintained by the English Telegraph Department since their acquirement, in 1889, from the Submarine Cable Company; the French Government repaying their proportion of the cost. In future, each government will be responsible for the maintenance of the cables entrusted to its care.

The Telegraph Lines and the Recent Gales.—The storm of Saturday night last caused considerable destruction to the telegraph lines, chiefly in the Midlands and in the Eastern Counties. The wires running along the Midland Railway route were very much damaged in places, and the Department's road lines *viâ* Dunstable, Weedon and Coventry to Birmingham, *viâ* Colchester to the Dutch and German cables, and *viâ* Peterboro' to the north, all came in for severe punishment. In addition, there were a large number of scattered faults. In most cases the wires have been put through, a large number of strong gangs being put on at once to repair the breakdowns. In nearly all cases the damage has been caused by falling trees. Hundreds of trees were reported down along the route of the line between Weedon and Coventry.

The Governing of Engines.—The governing of engines is an important matter to the electrical engineer. No book has yet been published on the subject, and we are therefore pleased to refer to a series of articles on "Engine Governors and Governing Mechanisms" which Mr. Robert Gordon Blaine, A.M.Inst.C.E., of the Finsbury Technical College, is contributing to the *Mechanical World*. This series should be of interest to all engaged in central station work. As a further reference to the subject, the student might look up Mr. Swinburne's paper read before the last B. A. meeting.

The Institution of Electrical Engineers.—At a Students' Meeting to be held in the library of the Institution, 28, Victoria Street, on Friday April 5th, 1895, at 8 p.m., the following paper will be read:—"The Practical Measurement of Self-Induction," by C. V. Drysdale.

City and South London Railway.—The Bill which seeks an extension of time until 1900 within which to enable the City and South London Railway to construct the authorised extension of their electric railway from Stockwell to Clapham has been referred to the Unopposed Bill Committee of the House of Commons, a settlement having been effected with the Lambeth Vestry, which was the only opponent.

Obituary.—The Dundee Press records the death of Mr. James Maxwell, an electrical engineer, who carried on business in that town.

The Faraday Medal.—On Wednesday, at the anniversary meeting of the Chemical Society, the Faraday medal was conferred upon Lord Rayleigh, F.R.S. Hitherto this medal had been awarded by the Society to foreigners only, and Prof. Fischer, to whom it had been offered, declined to accept it on account of his health. Under the circumstances the Council determined to break through their customary practice, and to give the medal to Lord Rayleigh in recognition of the extreme value of his researches, as well as of his unwearied perseverance and consummate skill. The Faraday lectureship goes with the medal, and Lord Rayleigh will probably address the Society on the subject of argon.

NEW COMPANIES REGISTERED.

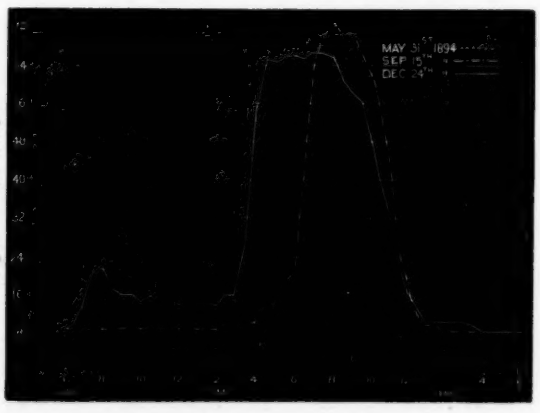
General Traction Company, Limited (43,610).—This company was registered on March 20th with a capital of £7, in £1 shares, to carry out contracts for making or purchasing and working railways, tramways, telegraph and telephone lines, electric and other lighting, electric, hydraulic and other works, &c. The subscribers (with one share each) are:—A. W. Lawson, 3, Holly Road, Leytonstone, clerk; E. B. Wyatt, 11, Highbury Crescent, N., clerk; T. Outen, 555, Caledonian Road, N., gentleman; P. J. Newton, 29, Evelyn Road, Richmond, clerk; S. H. Morison, Grosvenor House, Acton, gentleman; W. B. Butler, Blackburn Road, West Hampstead, secretary: E. T. Church, 41, Copleston Road, S.E., clerk. Registered without articles of association by Ashurst, Morris, Crisp & Co., 17, Throgmorton Avenue, E.C.

J. G. Bartlett & Co., Limited (43,623).—This company was registered on March 22nd, with a capital of £2,000 in £1 shares, to acquire, take over as a going concern, and carry on the business of a mechanical, electrical, hydraulic, and marine engineer, machinist, and brass and iron founder, carried on by Joseph G. Bartlett, trading as J. G. Bartlett & Co., at Redcliff Wharf, Redcliff Backs, Bristol. The subscribers (with one share each) are:—J. Bartlett, 24, Redland Road, Bristol, insurance agent; J. G. Bartlett, Redcliff Backs, Bristol, engineer; D. G. Bartlett, 24, Redland Road, Bristol, accountant; A. O. Dixon, Carlton Chambers, Bristol, insurance manager; T. Protheroe, 36, Wine Street, Bristol, artist; W. L. Gunn, 7, Bridgland Avenue, Bristol, chemist; J. S. Weston, Glebefield, St. George's, Bristol, mortgage broker. Registered without articles of association by Jordan & Sons, 120, Chancery Lane. Registered office, Redcliff Backs, Bristol.

CITY NOTES.

The Scarborough Electric Lighting Co., Limited.

This company has undoubtedly turned the corner. The profits for the year are not magnificent, neither are the costs of production quite as low as we should like to have seen; but we have not the slightest doubt that the company will be able to declare a small dividend next year. The company adopted at the outset the bold and vigorous policy of charging a low price for current, and no doubt the future working of the concern will show the wisdom of such policy; but, of course, the profits yielded in the early period of the company's existence must be small. Under the circumstances it is pleasing to find a balance of £418 remains to be carried forward to next year's accounts. No provision has been made for depreciation, but this no doubt will come after another 12 months' working.



Although a special sliding scale of cost of current varying from 6½d. to 5¾d. has been in existence, the average price obtained is slightly over 6d. It would scarcely be fair to say much about the details of the cost of production; coal is high, so are wages, but we have abundance of faith both in the system and in the management.

We note that, to meet the future increased demand, another set of plant of 100 H.P. has been ordered.

	1892.	1893.	1894.
Total capital expended ...	—	—	£25,987
Number of units sold	—	—	86,594
Number of lamps connected ...	—	—	—
Revenue from sale of current...	—	—	£2,186
Net revenue	—	—	£505
Average price obtained per unit	—	—	6·05d.

Cost of Production.	£	s.	d.	Per unit.
Coal	676	0	0	1·87d.
Oil, waste, water, and engine room stores	47	0	0	·13d.
Salaries and wages at generating station	568	0	0	1·57d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	146	0	0	(Works' cost 3·97d.) ·40d.
Rates and taxes	56	0	0	·161.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges and insurance	245	0	0	·68d.
Depreciation of buildings and plant account	—			—
Renewal fund account	—			—
Total	£1,738	0	0	4·81d.

Revenue.				Average price obtained per unit.
By sale of current	£2,186	7	11½	—
Meter rents	60	6	10	6·05d.
Sale of lamps	2	12	6	—
Total	£2,249	7	3½	6·05d.

Total cost per unit (exclusive of depreciation and renewal accounts), 4·81d.; works cost, 3·97d.

Burnley Corporation Accounts.

The principle of municipal ownership is being more and more justified by the accounts which we receive from time to time. Although the Burnley figures have been in our possession some days, we have deferred a consideration of them in order that we might do them adequate justice. The Burnley works have not existed in a complete form much more than 12 months, but the costs of production are as good as anything we have ever seen, and they reflect the highest credit both on the original design and the subsequent management of the works. What makes the low production cost of more than passing interest, is the fact that the output is a very small one, it being not more than 74,383 units. With the exception of Northampton and Burton, it is extremely unlikely that any other station will have so small an output for 1894, and Mr. Thursfield, the engineer in charge, may be congratulated on having one of the smallest outputs of corporation stations, and almost the lowest works' costs of any in the country. In making comments on the Burnley works, we ought to give prominence to the fact that they were designed and laid down by the engineer who had to run them. It is not necessary to say very much about the various items which make up the costs of production; the coal figure, ·62d, would be very hard to beat, and ·84d. and ·77d. for salaries and management respectively are exceptionally good. The works' costs stand at 1·80d., while the total costs are 3·10d. We have followed our usual practice in not taking into account repairs and maintenance of apparatus on consumers' premises, our contention being that meter rents give more than an average interest on the capital expended in meters, and this surplus, we think, can be fairly put against repairs. Still, we are open to conversion on this point, and should very much like to have opinions on the matter. The costs are as follows:—

	1892.	1893.	1894.
Total capital invested	—	—	£20,727
Number of units sold	—	—	74,383
Number of lamps connected ...	—	—	6,708
Revenue from sale of current...	—	—	£1,746
Net revenue	—	—	£829
Average price obtained per unit	—	—	5·64d.

Cost of Production.	£	s.	d.	Per unit.
Coal	192	0	0	·62d.
Oil, waste, water, and engine room stores	52	0	0	·17d.
Salaries and wages at generating station	259	0	0	·84d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	52	0	0	(Works' cost 1·80d.) ·17d.
Rates and taxes	163	0	0	·53d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	240	0	0	·77d.
Depreciation of buildings and plant account	294	0	0	·95d.
Renewal fund account	—			—
Total	£1,252	0	0	4·05d.

Revenue.	£	s.	d.	Average price obtained per unit.
By sale of current	1,746	0	0	5·64d.
Meter rents	54	0	0	—
Sale of lamps	—			—
Total	£1,800	0	0	5·64d.

Total cost per unit (exclusive of depreciation and renewal accounts), 3·10d.; works' cost, 1·80d.

The Burton Corporation Accounts.

When we penned the foregoing remarks about the value of municipal control, it might have been as well to have considered the dismal accounts of the Burton Coporation. They certainly constitute a record—at the wrong end. The total cost of production is 18·20d. per unit, which, when sold, averages 6d. It is certainly startling; but when one has finished startling, and comes to examine the accounts, much can be explained away. In the first place the consumption of current is most meagre, only 19,000 units having been sold during the period under review. We must also bear in mind that the accounts only cover 10 months' working. The consumption of current per lamp is exceedingly low, with a consequent minute revenue. Taking into consideration all the special circumstances that may have operated against the success of the works, it cannot be denied that the results are signally disappointing. We were watching with interest the experiment of utilising refuse from the gas works; but in face of the fact that £200 is given as the cost of fuel, one would really like to know a little more about the matter. It is useless to dwell very much on the details of the cost; they are too melancholy. We must say, however, that the salaries and wages (£471) seem to be excessive, considering the smallness of the station. Of course we are open to correction on this point, but it is distinctly our impression. It is to be hoped that the next 12 months may put a better complexion on the state of things; but after all, where is the demand for electric lighting in Burton, outside the breweries. The loss for the 10 months amounts to £1,802.

	1892.	1893.	1894.
Total capital invested	—	—	£27,000
Number of units sold	—	—	19,291
Number of lamps connected	—	—	—
Revenue from sale of current	—	—	£482
Net revenue	—	—	—
Average price obtained per unit	—	—	5·9d.

Cost of Production.	£	s.	d.	Per unit.
Coal	200	0	0	2·49d.
Oil, waste, water, and engine room stores	56	0	0	·70d.
Salaries and wages at generating station	471	0	0	5·86d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	8	0	0	(Works' cost 9·15d.) ·10d.
Rates and taxes	30	0	0	·37d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges and insurance	78	0	0	·97d.
Depreciation of buildings and plant account	707	0	0	8·80d.
Renewal fund account	—			—
Total	£1,550	0	0	19·29d.

Revenue.	£	s.	d.	Average price obtained per unit.
By sale of current	482	5	6	5·9d.
Meter rents	24	12	11	—
Sale of lamps	—			—
Total	£506	18	5	5·9d.

Total cost per unit (exclusive of depreciation and renewal accounts), 10·49d.; works' cost, 9·16d.

The Eastbourne Electric Light Co., Limited.

When we contemplate the early struggles of this company, the great and exceptional difficulties which it had to meet, it is particularly gratifying to note that the era of prosperity seems to have arrived. Though the cost of production is lower than last year, it is still fairly high; but the company continues to obtain an exceptionally good price for current, with the result that it has been enabled to declare a dividend of 7½ per cent. This is a really good performance, and the company is to be congratulated on its progress. Last year 5 per cent. was paid on the share capital. It was then contemplated to extend the company's operations by means of a private issue of debentures. This issue was created, and the extension has been apparently attended with the greatest possible success. There has been a satisfactory increase in the number of lamps on the company's circuits, the number of incandescents having risen from 8,454 8's at the end of 1893 to 12,056 at the end of 1894; the arcs have increased in the same period from 21 to 35.

The gross earnings for the year amounted to £5,910 10s. 9d., and the expenditure, including £400 carried to the depreciation fund account, to £3,337 10s., giving a gross profit upon the actual working of the company of £2,573 10s. After adding thereto the reserve of £295 13s. 8d. from last year's profits, and providing for all mortgage and debenture interest, a balance of £1,514 11s. 4d. remains. Out of this £300 is to form the nucleus of a reserve fund, which leaves £1,240, which is to be applied to the payment of a dividend of £7 10s. per cent., the balance, £441, is to be carried to next year's net revenue account.

We do not suppose that the full benefits of the extensions have been felt yet, because the district which has been opened up by the company has been only supplied with light since last October.

Compared with last year the coal figures are slightly better, while the cost of management has materially increased, despite the larger output. The total works cost for 1894 is 2·45d., against 3·75d. for the previous year; the total costs, including depreciation, are 5·21d., against 6d. for 1893.

The details of costs are as follows:—

	1892.	1893.	1894.
Total capital expended	—	£37,950	£44,137
Number of units sold	—	124,663	147,348
Number of lamps connected	—	8,454*	12,056†
Revenue from sale of current	—	£4,560	£5,323
Net revenue	—	—	£2,574
Average price obtained per unit	—	8·7d.	8·6d.

Cost of production.	£	s.	d.	Per unit.
Coal	842	0	0	1·37d.
Oil, waste, water, and engine room stores	102	0	0	·17d.
Salaries and wages at generating station	881	0	0	1·43d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	295	0	0	(Works' cost 3·45d.) ·48d.
Rates and taxes	38	0	0	·06d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	644	0	0	1·05d.
Depreciation of buildings and plant account	400	0	0	·65d.
Renewal fund account	—			—
Total	£3,202	0	0	5·21d.

Revenue.	£	s.	d.	Average price obtained per unit.
By sale of current	5,322	14	3	8·6d.
Meter rents	204	12	3	—
Installations	248	12	1	—
Total	£5,175	18	7	8·6d.

* Does not include 21 arcs. † Does not include 35 arcs.

Total cost per unit (exclusive of depreciation and renewal accounts), 4·56d.; works' cost, 3·45d.

The Managing Director of Henley's.

The Board of Directors of Henley's Telegraph Company fully recognise the ability and sound business methods of Mr. Sutton, their managing director, for, as will be seen from our City reports, they have made the unusual arrangement of engaging him for a term of ten years. There is no doubt that Mr. Sutton has been mainly responsible for bringing the company from the position it occupied a few years ago to its present prosperous condition, and it is pleasing to record that his great services are fully appreciated.

Corporation Accounts.

We should be glad if Borough Electrical Engineers and Town Clerks, when making up their electric lighting accounts, will kindly bear us in mind and send us a copy.

Reduction of Prices at Bournemouth and Chelsea.

It is satisfactory to record that the reduction of the price of current is becoming very general. The Bournemouth Company has decided to abolish a sliding scale, and to charge for current at the rate of 7d. instead of 8d. per Board of Trade unit. Where customers desire it, a demand indicator will be supplied, so that the large consumers will have the privilege of getting some of their supply at 5d. per unit.

From our "Notes" columns it will be observed that on and after a certain date the Chelsea Electricity Supply Company will reduce their rates per unit.

The Direct Spanish Telegraph Company, Limited.

The directors' report for the half-year ended December 31st, 1894, to be presented at the half-yearly general meeting of shareholders, to be held to-day, states that the accounts, after providing for debenture interest, and redemption of debentures, show a balance to the credit of revenue of £4,076 13s. 5d. The traffic receipts show a decrease of £1,244 7s. as compared with the corresponding period of 1893. This falling off in the receipts is due to the continued depression of trade between England and Spain and France and Spain. The working expenses are £40 13s. 3d. in excess of those for the corresponding period of 1893. The company's cables, and the landlines in connection with them have, with one exception, continued in good working order throughout the half-year. The Falmouth-Bilbao cable became interrupted on November 14th, 1894, having been broken by the British steamer *Caloric*, in Bilbao Bay. It was effectually repaired by the Eastern Telegraph Company's ss. *John Pender* on December 2nd, 1894. An action has been brought against the owners of the above steamship to recover the expenses and damages incurred by the act of their ship. The cost of these repairs has therefore been included in the amounts due outstanding. The company has opened branch offices on January 1st last at Liverpool and Manchester, and hope to derive increased revenue in consequence. After adding the usual sum of £2,500 to the reserve fund, the balance of revenue amounts to £1,576 13s. 5d. To this the directors propose to add £1,166 8s. 7d. from interest on investments, and recommend the payment of the dividend at the rate of 10 per cent. per annum on the preference shares, and a dividend, free of income tax, at the rate of 4 per cent. per annum on the ordinary shares. The reserve fund will then amount to £22,888 1s. 6d. Sir John Pender, G.C.M.G., M.P., and Mr. J. Denison Pender, are the directors retiring by rotation, and offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths & Co., retire, and offer themselves for re-election.

Scarborough Electric Supply Company.

The annual meeting of this company was held last Tuesday week, Mr. Geo. Alderson-Smith, who presided, said he thought it must be admitted on all hands that the report was an extremely satisfactory one, considering that it contained an account of their first year's working. During the first six months of the year they lost month by month, but during the last six they had not only cancelled that loss, but a profit had been left as shown on the balance-sheet. He thought they would see that there had been a steady progression towards a dividend in the future, and he did not think that future was very far distant. Looking at the capital expenditure for the past year, there had been an increase of £5,385. With regard to the revenue account, the rent of meters was only some £60, whereas the cost of them had been £960, but many of these meters did not come into use until the last quarter of the year, and consequently the rent from them in the coming year would be materially increased. They charged very low rates for their meters—far too low in the opinion of some people—but as he believed the gas company were not going to make any charge in the future, it was very desirable that they should put their charge as low as possible. They would see that the directors recommended that the balance should be carried forward. Depreciation had not been dealt with—the proper time to do so would be before they declared a dividend. Looking at the liabilities of the company, it would be noticed that the shareholders' capital was less than the capital outlay; that the sundry creditors were small in amount, and that the bank account was overdrawn. The bank account would be largely reduced when the amount due from sundry creditors (£1,154 odd) had been received. It appeared advisable, perhaps, in view of the probable extension of the company, to seek new capital, and on the publication of the figures and reports for the past year, he imagined this could easily be done. If this did take place it would only be fair to take such steps as would prefer, in the matter of the first dividend, the present shareholders on whom the risk of successful inception had fallen. He moved that the report and balance-sheet be received and adopted.

After some discussion, the report and balance-sheet were adopted.

Messrs. John Dale, J. B. Simpson, and J. W. Woodall were re-elected directors, and Mr. C. E. Bradley, auditor.

Eastbourne Electric Light Company.

The annual meeting of this company was held on Monday at the Gildredge Hotel, Eastbourne. Alderman Boulton (the chairman) who presided, said that he never shared the doubt which some people entertained as to the ultimate success of the company. The year before last they paid their first dividend, namely, 3 per cent.; last year they increased it by 2; this year they had added 2½, bringing it up to 7½, and next year they hoped to add another 2½. A reserve fund he felt to be very necessary in a company like that, and if constituted as recommended, might be applied not only to the objects mentioned in the report, but also to the equalisation of dividends. Having highly complimented the engineer upon the manner in which he had fitted the light in his house, the chairman mentioned that the directors proposed to reduce the cost of the light from June 30th next from 9d. to 8½d. per Board of Trade unit.

The Mayor seconded the motion, endorsing all the chairman had said, and speaking with confidence of the company being able to pay 9½ to 10 per cent. next year.

The motion was carried, and a special resolution declaring a dividend of 7½ per cent. was passed. Councillor Skinner was re-elected a director.

Mr. Hellins proposed a vote of thanks to the directors, and that £200 be paid to them as remuneration for their services during the past year.

The motion was adopted.

Messrs. Hart Bros., Tibbetts & Co. were re-appointed auditors.

Mr. Sumfield suggested that the company, seeing that it was in such a prosperous state, should make some recognition of the services of the manager and secretary.

The Chairman said that they had already done so by increasing their salaries.

Mr. Sumfield thought some honorarium in addition should be given them, and the Chairman promised that the suggestion should have the consideration of the directors.

Votes of thanks were passed to the manager and secretary for their efficient services since the formation of the company, and to the chairman for presiding.

Henley's Telegraph Works Company, Limited.

The ordinary general meeting of this company was held last Friday at the offices, Martin's Lane, Cannon Street, Mr. Sydney Gedge presiding.

In moving the adoption of the report, the Chairman said they had been doing a good, steady, and increasing business, and the ratio of profit had increased. The complications which they had had in the past, which arose in connection with the International Cable Company, were now at an end. They held shares in that company to the amount of £48,200, but against this they had provided a reserve of the same amount, and nothing was brought forward as of any value in connection with this asset. The whole of the item was written off, although a substantial sum was still coming from this source, which would be to the good next year. The whole of the debenture stock, £50,000, had now been subscribed for, and the expenses of the issue had been paid out of the year's profits, as had also all maintenance charges, together with £1,000 for depreciation of machinery. If their business continued to go on as at present, he thought that within a few months the shareholders would have to be asked for power to increase the capital of the company. When that was done he hoped they would be able to make some proposal for the benefit of their men at the works, the average number employed now being about 500. Not a shilling had had to be expended on repairing the Bahamas cable, which had now been laid for three years, or on the Bermuda cable.

Mr. R. J. Jenkins seconded the motion, which was adopted.

A resolution was also passed authorising the directors to engage Mr. Sutton as managing director for a term not exceeding 10 years.

The Eastern Telegraph Company, Limited, announce the payment on April 11th of interest of 3s. per share, less income-tax, being at the rate of 6 per cent. per annum on the preference shares for the quarter ending March 31st; and the usual interim dividend of 2s. 6d. per share on the ordinary shares, tax free, for the quarter ended December 31st.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending March 24th, 1895, amounted to £893; week ending March 25th, 1894, £792; decrease, £101; total receipts for half-year, 1895, £11,716; corresponding period, 1894, £11,192; increase, £524.

The Liverpool Overhead Railway Company. The traffic receipts of this railway for the week ending March 24th, 1895, amounted to £943; corresponding week last year, £797.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 22nd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,411.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Pres issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation March 20th.	Closing Quotation, March 27th.	Business done during week ended March 27th, 1895. Highest.	Lowest
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	...	4 %	4 %	101 —104	101 —104	...	..
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 15s.	£2 11s.	£2 2s.	41½— 42½	41½— 42½	42¼	41⅜
2,993,560£	Do. do. 6 % Pref.	Stock	£5 10s.	£5 2s.	£4 4s.	78½— 79½	78½— 79½	79½	78⅜
2,993,560£	Do. do. Defd.	Stock	...	...	...	6¼— 6⅜	6¼— 6⅜	6½	6⅜
130,000	Brazilian Submarine Teleg., Ltd.	10	6½% §	6½% §	...	12¼— 12⅜	12 — 12½	12 7/16	12 5/16
75,000£	Do. do. 5 %, repayable June 1906	100	5 %	5 %	...	109 —113	109 —113	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 40,000	5	10% ‖ §	... §	...	3 — 4	3 — 4	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	148 —152 xd	148 —152	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	2 % §	...	1/16— 3/16	1/16— 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	13 — 14	13 — 14	13⅜	...
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	20 — 21	20 — 21	20⅝	20¼
12,931	Direct Spanish Teleg., Ltd., £4 paid	5	4 %	4 %	4 %	4 — 4½	4 — 4½	...	...
6,000	Do. do. 10 % Pref.	5	10 %	10 %	10 %	9½— 10	9½— 10	...	...
30,000£	Do. do. 4½ % Debs of £50, Nos. 1 to 1,600	...	...	...	4½%	103—106%	103 —106%	...	...
60,710	Direct United States Cable, Ltd., 1877	20	3½% §	2⅝% §	2 %	8½— 9	8½— 9	8⅛	...
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½% §	...	16¼— 16½	16½— 16½	16½	16¼
70,000	Do. 6 % Pref.	10	6 % §	6 % §	...	17¼— 17¾	17¼— 17¾	17 9/16	17⅜
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	...	105 —108	105 —108	..	...
1,297,837£	Do. 4 % Mort. Deb.	Stock	4 %	4 %	...	124 —127	124 —127	125½	124½
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	...	17⅛— 17⅜	17⅛— 17⅜	17⅜	17⅛
54,100£	{ Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326 }	100	5 %	5 %	...	103 —107	103 —107	...	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	...	104 —107	104 —107	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	...	123 —126	123 —126	124½	...
95,100£	{ Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343 }	100	5 %	5 %	...	103 —107	103 —107	104	...
129,100£	Do. do. do. to bearer, 2,344 to 5,500	...	5 %	5 %	...	104 —107	104 —107	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 2,016, red. 1909	100	4 %	4 %	...	106 —109	106 —109	107	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	...	112 —115%	112 —115%	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅞% §	4⅝% §	...	9⅞— 10⅛	9⅞— 10⅛	10 1/16	9⅞
180,042	Do. do. 6 % Pref.	10	6 % §	6 % §	...	16⅝— 16⅞	16⅝— 16⅞	16⅞	16½
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅗% §	8⅗% §	...	21¾— 22¼	21¾— 22¼	...	...
190,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	...	104 —107	104 —107	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	...	52 — 54	52 — 54	...	...
37,548	London Platino-Brazilian Teleg., Ltd.	10	2 %	2½%	...	5 — 7	5 — 7	...	...
100,000£	Do. do. 6 % Debs.	100	6 %	6 %	...	105 —109	105 —109	...	...
15,000	Monte Video Teleph. Co., Ord., 1 to 15,000	5	...	...	...	... — ...	... — ...	...	...
28,000	Do. do. 6 % Pref., 1 to 28,000	5	6 %	6 %	...	1½— 2⅛	1½— 2⅛	...	...
484,597	National Teleph., Ltd., 1 to 438,984	5	5 % §	5 % §	5 %	5½— 5⅝	5½— 5⅝	5 7/16	5 5/16
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	...	15 — 16	15½— 16½	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	...	14½— 15½	14½— 15½	15½	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 90,950	5	5 %	5 %	...	5⅝— 5⅞	5⅝— 5⅞	5 13/16	5 11/16
1,100,000£	Do. 3½ % Deb. Stock Red.	...	3½%	3½%	...	104 —106	104 — 106	105½	104
48,800	New Teleph., Ltd., 25,901 to 74,700; £4 paid	10	...	...	...	... ...	... ...	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	...	...	9/16 — 11/16	9/16 — 11/16	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	105 —108	105 —108	...	...
11,839	Reuter's Ltd.	8	5 %	0 %	...	4 — 5	4 — 5	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	119 —124	119 —124	...	...
58,000	United River Plate Teleph., Ltd.	5	...	...	...	1 — 2	1 — 2	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	5 %	85 — 90	85 — 90	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	..	0 %	...	4 — 5	4 — 5	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	...	101 —104	101 —104	...	...
30,000	West Coast of America Teleg., Ltd.	10	...	...	...	1½— 2½	1½— 2½	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	...	98 —103	98 —103	...	...
64,245	Western and Brazilian Teleg., Ltd.	15	2½%	2½%	3½%	10 — 10½	10 — 10½	10½	10¼
33,129	Do. do. do. 5 % Cum. Pref. ...	7½	5 %	5 %	5 %	6¼— 6⅝	6¼— 6⅝	...	...
33,129	Do. do. do. 5 % Def.	7½	...	...	...	4 — 4½	4 — 4½	4½	4⅜
171,900£	Do. do. do. 6 % Debs. "A," 1910 ...	100	6 %	6 %	6 %	101 —105	101 —105	103¾	102¾
214,800£	Do. 6 % Mort. Debs., series "B," red. Feb. 1910	100	6 %	6 %	6 %	101 —105	101 —105	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅛%	⅜%	⅝%	⅞— 1⅛	⅞— 1⅛	1⅛	...
34,563	Do. do. do. 6 % 1st Pref. ...	10	6 %	6 %	6 %	10¾— 11¼	10¾— 11¼	11⅛	...
4,669	Do. do. do. 6 % 2nd Pref. ...	10	6 %	6 %	6 %	9 — 10	9 — 10	9¾	...
80,000£	Do. do. 5 % Debs. (1917) No. 1 to 1,000	100	5 %	5 %	5 %	108 —111	108 —111	...	...
$1,211,000	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ..	$1000	7 %	7 %	7 %	115 —120	115 —120	...	...
166,900£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	101 —103	101 —103	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	5 %	4¼%	4½%	5 — 5⅛	5 — 5⅛	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	...	5 %	13 — 14	13 — 14	...	...
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	15 — 15½	14⅜— 15¼	15¼	15
100,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	133 —136	133 —136	135½	...
50,000	†Liverpool Electric Supply, all paid	5	5 %	5 %	5½%	7 9/16— 7⅝	7⅛— 7⅜	7 9/16	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000	10	2 %	2½%	...	10¼— 10¾	10¼— 10¾	10¾	10 7/16
100,000£	Do. 5% Deb., bonds of £10, £20, £40	...	5 %	5 %	...	... — ...	... — ...	...	...
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	...	118 —120	118 —120	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	...	1 %	7¼— 7¾	7¼— 7¼	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-18,780	5	7½%	4½%	6½%	7½— 8	7½— 8	7⅝	7½
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	8½— 9	8½— 9	...	...
59,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	3½%	4 %	5 %	7½— 8	7½— 8	7⅞	7¾

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1892.	1893.	1894.	Closing Quotation, March 20th.	Closing Quotation, March 27th.	Business done during week ended March 27th, 1895. Highest.	Lowest.
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000...	3	6 % §	6 % §	...	2⅛ — 2⅜	2⅛ — 2⅜	2⅜	2⅛
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 % §	6 % §	...	2⅛ — 2⅜	2⅛ — 2⅛	2 5/16	2⅛
125,000/	Do. do. 4½ % Deb.	Stock	4½%	4½%	...	113 —116	113 —116	113½	...
630,000/	City and South London Railway	Stock	⅝%	⅝%	1¼%	45 — 47	45 — 47	...	...
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	7 % §	7 % §	...	2¾ — 3¼	2¾ — 3¼	...	...
50,000/	Do. do. 5 % 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	5 %	5 %	...	102 —107	102 —107	...	...
120,000	Electric Construction, Ltd., 1 to 120,000	2	*nil*	*nil*	...	¼ — ⅛	¼ — ⅛	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	...	1¼ — 1⅝	1¼ — 1⅝	...	...
100,000	Elmore's French Patent Cop. Deposg., Ltd., 1 to 66,750 ...	2	*nil*	*nil*	...	... — ...	... ...	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	1½ — 1⅝	1½ — 1⅝	1 5/16	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	1½ — 1⅝	1½ — 1⅝	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300	5	*nil* §	*nil* §	...	½ — 1½	½ — 1½	...	...
9,600/	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	7 %	*nil*	...	6½ — 7½	6½ — 7½	...	...
6,837	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	5 %	6 %	10 — 11	10 — 11	10¾	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	12½%	10 %	22 — 23	22 — 23	22⅝	22⅛
200,000/	Do. do. do. do. 4½ % Deb., 1896	100	4½%	4½%	4½%	103 —106	101 —103	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	...	1 %	1½%	8½ — 8⅝	8½ — 8⅝	...	...
6,295	† Do. do. Pref., £10 paid	10	...	5 %	5 %	13⅓ — 14	14 — 14½	...	...
	Swan United Electric Light, Ltd.	...	10 % §	7½% §	...	... — ...	... — ...	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	15 %	20 %	20 %	39 — 41	39 — 41	40¾	40
150,000/	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	104 —107	104 —107	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000, £2 paid ...	10	...	...	...	2⅜ — 2⅝	2¼ — 2½	...	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—8%.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5¼—5⅜.
Electric Construction Corporation, 6 % Debentures, 93—97.
Electric and General Investment, shares of £5 (£1 paid), 1½—2
House-to-House Company (£5 paid), 3½—4.
Do. do. 7 % Preference, of £5, 7⅛—7¼.
Do. do. 6 % Debentures of £100, 106—108.
Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 7—7¼; 1st Preference Cumulative 6 %, £5 (fully paid), 7—7½.
Liverpool Electric Supply, £5 (fully paid), 6⅞—7.
London Electric Supply Corporation, £5 Ordinary, ¼—½.
Queen Anne's Mansions Lighting and Heating Company, 6 % £100 Debentures, 99—101.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 5¼—5⅜.

Bank rate of discount, 2 per cent. (February 22nd, 1894).

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

The Electrolysis of Gold. By N. S. Keith, Member. Paper read March 14th, 1895.

(*Concluded from page* 367.)

The Anode is composed of sheets of iron one-eighth of an inch thick, exposing, in four vats, 14,784 square feet to electrolytic action. Each of the 356 iron plates is "cased in canvas to retain the small quantity of Prussian blue produced" (Butters and Smart), but also to retain the *large* quantity of ferric oxide produced. Von Gernet and Eissler state that the object of the "canvas is to prevent short circuits." This last is an obvious precaution and result, owing to the close proximity of anode and cathode. We gather from the papers cited that an iron anode has been adopted after trying both carbon and zinc. Eissler says: "Carbon could be used as an anode, but it will not withstand the action of the current, and soon crumbles into a fine powder which decomposes cyanide. This finely divided carbon is in suspension, and cannot be removed from the solution by filtration."

Weightman states that he has "been using 'good arc lamp carbons,' and carbon in other forms, for the last six months, and they are still in excellent condition."

Von Gernet says in his paper on the subject, read last October before the South African Metallurgical Society, at Johannesburg: "Zinc used as an anode forms a white precipitate of ferro-cyanide of zinc by the reaction of zinc oxide upon ferro-cyanide formed during the leaching. Similarly, iron anodes form Prussian blue by the reaction of oxide of iron and ferro-cyanide."

Let us consider these anodes. Owing to the fact that there must be an analysis (decomposition) of the electrolyte at the anode, electric energy is absorbed, or rendered latent there; and if the material of the anode does not combine with the anion set free, to form a compound therewith, that energy is lost. Generally, and in this case, oxygen is directly or indirectly the anion, and as it cannot combine with a carbon anode, for instance, it escapes from the anode to the air as gas. The carbon anode is practically *chemically* unacted upon by the oxygen anion, but is *mechanically* disintegrated thereby, and the more rapidly the greater the current, and therefore of the escape of gas. Carbon is objectionable as an anode pure and simple, because of these two properties. But it is further objectionable because the oxygen, reacting on the potassic cyanide, forms potassic cyanate, which is inoperative as a solvent of gold. So not only is the energy lost, but also the active ingredient of the electrolyte, making it inoperative as a subsequent solvent. Von Gernet's statement as to zinc is not clear. A very little ferro-cyanide should be formed during the leaching process. More likely the "white precipitate" is an insoluble coating of zinc oxy-compounds with cyanogen formed on the zinc anode. This coating offers great resistance to the electromotive force, so that it has to be increased to pass the necessary current; and this in its turn increases the difficulty. Much oxygen is set free, causing the corresponding wastes. So far we now have only the iron anode to consider, as it has been adopted, and is used, at the mines. Practically, the iron anode is oxidised by reason of the current, and it takes a definite amount of electric current to oxidise a definite amount of iron, the iron ampère-hour being 16·3 grains. The amount of iron used in the month of August was 1,080 lbs. This equals 1,080 × 7,000 = 7,560,000 grains. Providing this was all oxidised, the ampère-hours were $\frac{7,560,000}{16·3} = 463,803$. According to Von Gernet, the ampères were produced by 4 volts; therefore there were in a month $\frac{463,803 \times 4}{746} = 2,487$ H.P.-hours. The electric energy was 3½ H.P.; therefore was used $\frac{2,487}{3·5} = 710$ hours in a month of 31 days, or 744 hours—a curious coincidence. But Eissler says the pressure was 7 volts, and Butters and Smart say the dynamo used gives 300 ampères at 10 volts. These latter statements, taken with the probable conditions that there are undoubtedly some wastes of iron in the way of unoxidised scrap, and possible intermissions in current, are probably nearer correct. Taking 300 ampères for 700 hours, we have an oxidation of iron $\frac{300 \times 700 \times 16·3}{7,000} = 489$ lbs., and a scrap waste of 1,080 − 489 = 591 lbs. Evidently we need some more exact information for theoretical considerations. For this current—assuming the minimum statement be correct—300 ampères, the gold deposit was 697 ozs. 15 dwts. 15 grs. = 335,935 grains. According to our gold ampère-hour equivalent of 38·1, this quantity requires 8,817 ampère-hours to deposit; but to do this 300 × 700 = 210,000 ampère-hours were expended—about 24 times too much, if the proper association of materials had been made so that all the economic actions went on in the electro-chemical equivalents to the gold. Upwards of 200,000 ampère-hours were expended in decomposing water and setting free hydrogen.

The Cathode is of sheet lead. It was adopted, according to Von Gernet, as best satisfying the following conditions:—

"1. The precipitated gold must adhere to it.

"2. It must be capable of being rolled out into very thin sheets to avoid unnecessary expense.

"3. It must be easy to recover the gold from it.

"4. It must not be more electro-positive than the anode, in order to prevent return currents being generated when the depositing current is stopped. The most suitable metal for the purpose is lead, ... and meets all the requirements of the case."

These four requirements are very good, and should be, with others, carefully attended to. There is no exception to be taken to the first, within practical bounds. To the second, we say the cathode should be as thin as is consistent with mechanical stability; and most assuredly as thin as possible when wasted absolutely, as it is in practice, at the rate of 750 lbs. per month, in a small plant. A far better cathode is one which does not deteriorate, and practically is not wasted at all.

To the third, we say that it is not "easy" to recover the gold from the lead cathode. The necessary melting and cupellation is an expensive process—much more so than is the recovery of gold from the amalgam from a mercurial cathode, by distillation, or "retorting," as is continually practised in the metallurgy of gold. To the fourth, we say that a lead cathode *is more* electro-positive than an iron anode in a cyanide solution, and, therefore, does not fill the requirement. Furthermore, as soon as the lead cathode becomes coated with gold it becomes a gold cathode, which is electro-positive to the iron anode, therefore defective so far as this reqnirement is concerned. According to Von Gernet, a mercury cathode has been tried, but is impracticable on account of the large amount necessary to carry on the operation—say 80 tons to a small plant. "Sheets of solid metal (as copper) coated with mercury have also been tried, but have been unsuccessful, because the mercury, owing to the action of the current, will penetrate the copper and form a dry amalgam, which does not adhere to the plate." The mercury does not penetrate the copper plate any sooner than it does in the ordinary copper-plate amalgamation of the gold mills. That it forms a "dry" amalgam with the small amount of mercury which a vertically-placed copper plate will alone retain is evident. But the copper-plate cathode could be occasionally refreshened with mercury by sprinkling to the extent of keeping the amalgam plastic, but not so thin as to run off. I prefer to furnish the mercury necessary on a copper-mercury anode by the direct electro-deposition of mercury with the gold from the electrolyte.

The Current.—This is variously stated by the different authors quoted as from 300 to 600 ampères with pressures of from 10 down to 4 volts. Without unnecessary wastes, the current sufficient to deposit 697 ozs. 15 dwt. 15 grs., equal to 335,935 grs., of gold in 700 hours is $\frac{335{,}935}{700 \times 38{\cdot}1} = 12{\cdot}6$ ampères. Von Gernet says: "In a fixed time a given electric current will deposit a certain quantity of metal, which quantity varies for different metals in direct proportion to their electro-chemical equivalents. This law holds good only for solutions strong in metal; but with dilute solutions, as in use in the cyanide process, the current does not find sufficient of the metallic compound present at the electrodes, and consequently decomposition of water also takes place. For this reason, to make the efficiency of the precipitation as great as possible, constant diffusion of the solution is requisite." This explanation contains the essence of the whole matter. The efficiency is only from $\frac{12{\cdot}6}{600} = 2{\cdot}1$ per cent., to $\frac{12{\cdot}6}{300} = 4{\cdot}2$ per cent. In most of industrial operations we would consider such efficiencies exceedingly low. The waste of energy to produce the current, the waste of cyanide to produce Prussian blue, the waste of iron to make oxide and Prussian blue, the waste of lead to produce oxide of lead, and the waste of labour in handling these unnecessary quantities, add to the *necessary* expense of electrolytic treatment of auro-cyanide solutions at least £130 in a 3,000-ton per month plant, or 10·4d. per ton.

It will be asked, "Why these wastes, and can they be avoided without substituting others equally as expensive?" These expenses are due primarily, and mainly, to the improper selection of electrodes. The anode should be soluble under the electric current in the electrolyte in which it is immersed, for at least two reasons—(1) that it may communicate to the circuit the energy due to the combination of the metal of the anode with the anion; (2) that the compound thus formed may be removed by the electrolyte to expose a fresh metallic surface for the continuation of the operation in regular progression.

Iron is not soluble in cyanide of potassium solutions. It is, as I have before stated, strongly electro-negative in such solutions to all other metals which may be met with in the operation. The anode should be electro-positive to gold. Copper is so, but it would enter the solution at the expense of the cyanogen. Besides, it would be deposited on the cathode after a time, and render the gold impure. Carbon is not suitable, because in the cyanide it causes the formation of cyanate, and, besides, it is strongly electro-negative to a gold cathode. Zinc is electro-positive to gold in the electrolyte; but, as before stated, there forms upon it an insoluble coating impenetrable to moderate voltage of electricity. With iron it is necessary to raise the pressure of the current to overcome the resistance of the oxide and Prussian blue on its surface. But if it be arranged so that the anode be soluble, the current may be of very low voltage; and even it may contribute energy to the circuit. The way to secure this *desideratum* is to provide an electrolyte for the anode which will promote its solution. To do this the selected electrolyte must be mechanically separated from the cyanide electrolyte. This can be done by the use of porous cells, such as are used in various of the forms of galvanic batteries. The electrolyte in the porous cell, for convenience called the anode-electrolyte, must be of such a composition that the accidental mixture of it with the cyanide solution, for convenience called the cathode-electrolyte, will not injure the latter, nor confer upon it deleterious qualities. Such an electrolyte is found in aqueous solutions of ammonium salts, such as the chloride, bromide, and sulphate of ammonium. Zinc or iron anodes placed in such electrolytes, in porous vessels immersed in the cathode-electrolyte, will be readily dissolved, by reason of the formation of soluble double salts of the metal with ammonium.

With an iron anode in the cyanide solution it is necessary to raise the voltage to cause the current to pass the oxides, &c. In doing so, there is an evolution of much free oxygen, with corresponding loss of electrical energy. But that is comparatively a minor defect. It also sets free a corresponding amount of hydrogen at the cathode. These two gases accumulate, each on its appropriate electrode, until their comparative levity causes them to escape against the pressure of the electrolyte. But they continually cover a very large part of the electrode surfaces, and thus keep from them the electrolyte, which should be in contact therewith. If this action be prevented, the electrode surfaces need not be nearly as large for the same amount of deposition of gold. In order to force the deposition, then, the voltage is raised to from 4 to 10 volts, though one-quarter of a volt is sufficient to produce the necessary actions and reactions under proper assemblages of materials as to quality, size, and position. If the analysis (decomposition) and synthesis (composition) be equal, no energy is absorbed other than to overcome the resistance. As the resistance is small, owing to the large cross section of electrolyte and small distance between electrodes, a very small electromotive force is necessary when the proper electrode, and electrolyte for it, are used. Take such an assemblage, and the work of depositing 697 ozs. of gold should be done with the expenditure of $12{\cdot}6 \times 0{\cdot}25 = 3{\cdot}15$ watts, for 700 hours, instead of $300 \times 10 = 3{,}000$ watts for the same time.

If iron had been used in a proper electrolyte, the iron dissolved would have been as 65·5 : 28 :: 697 : 298 ozs. of 480 grs., equal to $\frac{298 \times 480}{7{,}000} = 20{\cdot}4$ lbs., in place of 1,080 lbs.—a saving of 1,060 lbs. But iron would have used, say, about 40 lbs., including waste, of ammonium sulphate in the anode electrolyte—worth about 55d.

If zinc had been used in a suitable electrolyte, the amount would have been 65·5 : 32·5 :: 697 : 345 ozs. of 480 grs., equal to 23·6 lbs., with a like consumption of ammonium salt. By the direct zinc precipitation in the McArthur-Forrest process, according to Eissler, there is a consumption of zinc varying from 0·25 to 0·50 lb. per ton of ore—say, an average of 1,000 lbs. for the quantity of gold produced (697 ozs.) from 3,000 tons of auriferous tailings. There is in this item alone a saving possible of £18 sterling per month.

In the *Proceedings* of the Engineers' Club of Philadelphia, for November, 1894, there is a paper entitled "The Electro-Metallurgy of Gold and Silver," by A. L. Eltonhead, in which he describes an alleged process of separating gold from cyanide solutions, said to be used in a "small plant" by "the electro-chemical process (patent applied for) on the west side mine of the Tombstone Mill and Mining Company, of Tombstone, Arizona." The writer of the paper was evidently not fully posted as to the process, and did not mention the name of the "inventor" (?).

The description is somewhat vague and imperfect; but we gather that the "precipitating box is of novel construction," is 10 feet long, 4 feet wide, and 1 foot high, divided into "five lengthwise compartments." "Under each partition grooves may be cut, a ¼ to ½-inch deep, extending parallel with the partitions, to serve as a reservoir for the amalgam, and give a rolling motion to the solution as it passes along through the four [*sic*] compartments. The centre compartment is used to hold the lead, or other suitable anode, and electrolyte." "The electrolyte may consist of saturated solutions of soluble alkaline metals and earths. The sides or partitions of each compartment dip into the mercury, which must cover the 'box' evenly on the bottom to the depth of about ½-inch. Amalgamated copper strips or discs are placed in contact with the mercury, and extend above it, to allow the gold and silver solution of cyanide to come in contact. The electrodes are connected with the electric dynamo, the anode of lead being positive, and the cathode of mercury being negative. The dynamo is started, and a current of high ampèrage and low voltage is generated, generally 100 to 125 ampères, and with sufficient pressure to decompose the electrolyte between the anode and cathode. As the gas is generated at the anode a commotion is created in the liquid, which brings fresh and saturated solution of electrolyte between the electrodes for electrolysis, and makes it continuous in its action."

There seems to be a distinction between the "electrolyte" and the "solution of double cyanide of gold and potassium;" but where they are separated and how, if at all, does not appear. There is a "half-tone" picture of the "box," but it gives no more information than does the above description. The anode surface is about 16 to 18 square feet, which can be made less by raising with thumb-screws. The cathode surface may be about 40 square feet.

With a current of 125 ampères we should judge that "the gas creates a commotion," and such a commotion that it would be wonderful if the process be speedy, and otherwise than "continuous."

From the principles involved, which we have considered, this "process" may be set aside. Yet it is but one of the many suggestions, or attempts, made by "inventors" (?) unacquainted with the electrical and chemical requirements. We have not the time to consider more of these within the limits of this paper. We know that oftentimes more is learned through failures than through successes, so we may consider these and the fallacies at some other time.

After thorough experimenting and test, I have devised and patented throughout the gold-producing countries of the world the following described process for electrolytically obtaining gold and silver from auriferous and argentiferous rocks and ores:—Sufficient solution of cyanide of potassium, of a strength varying from 2 to 10 lbs. of cyanide to each ton of water, with from 2 to 10 ozs. of a soluble salt of mercury, is prepared. The finely pulverised ores, or tailings, are

submitted to the leaching process with this solution, as in the other cyanide processes. The electro-positive gold in the tailings decomposes the mercury salt which comes in contact with it, and thereby produces voltaic couples of mercury and the minute particles of gold, thus hastening the solving of the gold.

As the speed of solving is dependent upon the actual contact of the gold and mercury with the cyanide of potassium, it is preferable to keep the solvent in constant motion during the percolation or leaching, so that fresh solvent, not exhausted of its cyanide, may continually be in contact with the gold. To accomplish this, the whole or part of the solvent is frequently drawn from the leaching vats, or is continuously passed through the tailings, until the solving action is completed. In this way much weaker solutions may be used than is the case where the cyanide solution is allowed to stand for long stated periods in the tailings. The weak solutions are preferable, because the losses in material are not so great, and they are equally as good solvents as the strong, though not so speedy.

As the solutions come from the leaching vats, they are run continuously through electrolytic precipitating, or depositing vats, constituted as follows:—Long boxes are provided, say a little over 2 feet deep and 2 feet wide, containing copper plates 24 inches square, and crossing the boxes every 1½ to 2 inches, but placed so that every alternate plate rests on the bottom and sides of the boxes, and the intermediate plates are raised about half an inch above the bottom of the box.

The number of plates and the length of the boxes are sufficient to permit of the deposition on them of all the metal constituents of the solution without so great a density of current that hydrogen is deposited likewise. If the solution be kept sufficiently in motion, the density may be 0·1 ampère per square foot of cathode surface; but, as the solution becomes much weaker in metal towards the latter end of the vat or box, the density there cannot be so great. But this matter is self-regulating, because the greater tendency to polarisation impedes the passage of the current at the latter, and weaker end.

On the average basis of a density of current of 0·06 ampère per square foot, a cathode surface of 800 square feet is ample for a plant treating 3,000 tons of average tailings per month. One hundred plates of the size named supply this amount of surface. These plates are preliminarily amalgamated with mercury, and are each connected with a 'bus bar which is connected with the negative pole of the source of electricity.

Between these cathodes are placed porous cells filled with a half-saturated, or other strength, aqueous solution of an ammonium salt, such as the chloride or sulphate. Into each cell is placed a rod, strip, or prism of zinc or iron, and each of these is connected by wire to another 'bus bar, which is connected with the positive pole of the source of electricity.

The cyanide solution of gold and mercury is passed continuously through this vat, tank, or box, in a steady stream, and at a rate which ensures the deposition of a greater part of its metallic contents. If the quantity of mercury on the copper plates, together with that which is deposited from the solution, be not enough to keep the amalgam in a sufficiently plastic condition, more mercury solution may be added to supply mercury for that purpose. If it be too soft the amount of mercury solution may be decreased. No mercury is lost, because recovered by the electrolytic deposition.

Because the gold is deposited in exceedingly attenuated particles, the amount of mercury necessary to form with it a plastic amalgam is much in excess of the quantity of gold—say three or four times as much. This relation varies with the rate of deposition of gold. Take, for example, 12·6 ampères to deposit 1 oz. of gold per hour, and 29 ampères to deposit 3½ ozs. of mercury in the same time, and we have the practical requirement of 41·6 ampères to deposit 1 oz. of gold per hour. This for 744 hours per month is enough to more than deposit the 697 ozs. produced per month by the use of 300 ampères for the same time, in the case illustrated by the authors referred to hereinbefore.

Because the anode is rendered soluble by putting it in a suitable electrolyte, there is no consumption of energy in the actions which there take place. There is no escape of uncombined or free oxygen. A zinc anode is electro-positive to the mercury cathode to the extent of 0·25 volt—in itself sufficient to cause the deposit. When the anode-electrolyte has become exhausted as an electrolyte by the formation of double salts with the metal of the anode, the porous pots have their liquid contents removed, and new electrolyte substituted therefor. Porous pots are used an inch or so in diameter and 24 inches deep; eight or ten in each space between the cathodes are sufficient.

The cathode, though in its substance mainly of copper, is, electrically, a mercury one; therefore, not as strongly electro-positive in its electrolyte as is a copper one. But the anode is sufficiently electro-positive to it to keep the cyanide solution from dissolving the gold and mercury when the dynamo, or other source of electricity, is unconnected, provided the anode and cathode be connected electrically.

The depositing vat can be, and is preferably, worked continuously. The anode parts are supplied from time to time as fast as dissolved. The anode-electrolyte is renewed from time to time, as necessary, by the use of a hand pump. The amalgam is removed whenever desired from the cathode plates. For this purpose they can be disconnected from the 'bus bar one by one, removed from the vat readily, the amalgam scraped off, and the plates returned to the vat. There is, necessarily, no wholesale removal of electrodes, as, for instance, in the previous case, when the iron plate anodes become full of ragged holes from corrosion, or when the lead cathodes were removed to be melted and cupelled. The amalgam is "retorted," as in the usual routine of gold amalgamation—a much simpler and less expensive operation than melting and cupelling. Practically no mercury is lost; but lead cathodes are lost.

The electromotive force necessary to carry out this process does not exceed ½ volt. Whatever there be more than that would be expended in decomposing the water of the electrolyte, thus unduly oxidising the anode, and setting free hydrogen at the cathode to no good effect; but rather cover the cathode with hydrogen films, and to that extent reduce the surface available for receiving the metal deposit, thus increasing the resistance and lessening the current. In the effort to increase the metal deposit by raising the voltage, we would meet the same difficulty as is experienced with the said Siemens and Halske process, and find, as Von Gernet says, "a better effect is gained by doubling the surface than is obtained by increasing the current ten-fold."

The expense of working 3,100 tons of tailings in August, 1894, at the Worcester Mill, in Johannesburg, by the Siemens and Halske process, as stated by Eissler, was, in detail, as follows:—

	£		d.	
Filling and discharging leaching vats	125	monthly	10	per ton.
Cyanide...	75	"	6	"
Lime	15	"	1·2	"
Caustic soda	6	"	0·5	"
Lead	14	"	1·1	"
Iron	28	"	2·2	"
White labour	65	"	5·2	"
Native wages and food	20	"	1·9	"
Coal	57	"	4·6	"
Stores and general charges	41	"	3·2	"
Total	£450	or	3s.	per ton.

By the improved electric process at least £130, or 10 6d. per ton, can be saved in expense in the following items:—One-half of the cyanide, all of the lead and iron, 10 per cent. of the labour, and three-quarters of the coal.

There would be wasted by the new process, say, 25 lbs. of zinc, worth at the mines about 19s., and about 5s. to 10s. worth of ammonia-salt—about 0·11d. per ton.

The use of strongly alkaline solvents is desirable during the dissolving stages of a cyanide process, because the alkali serves to decompose various salts and oxides, such as ferrous sulphate and oxide, ferric sulphate, and sulphates of aluminium and magnesium, &c., which would otherwise decompose the cyanide.

But alkali is inadmissible when zinc precipitation follows, because of the increased waste of zinc caused thereby in the formation of zincate of the alkali.

The alkali is inadmissible when chlorine, iodine, bromine, and such like "cyanicides" are used, because they expend their action on the alkali instead of where desired.

By my electrolytic process the solvent may be very strongly alkaline without detracting from its desirable solvent action, but, rather, adding to its efficiency, and decreasing what would otherwise be the solvent action on other constituents of the ores.

THE TELEPHONE SERVICE: PARLIAMENTARY INQUIRY.

The Select Committee of the House of Commons appointed "to consider and report whether the provision now made for the telephone service in local areas is adequate, and whether it is expedient to supplement or improve this provision, either by the granting of licenses to local authorities or otherwise," met for the first time to take evidence on Friday, when Mr. Arnold Morley (Postmaster-General) presided.

Mr. G. C. Lamb, assistant secretary of the Post Office, in charge of the Telegraph Department, was the first witness examined, and said that the first telephone was brought to England in 1876; but it was then in a very crude form, and what might be called the first practical telephone was brought from America in 1877 by two officers of the Post Office, Mr. Preece and Mr. Fisher. At that time the Post Office had an exchange system worked by telegraph instruments, which was started in Newcastle-on-Tyne by the Universal Telegraph Company in 1864, and was absorbed by the Post Office in 1868 under the Telegraph Act. Under this system one subscriber was put into communication with another by means of a switch. The A B C telegraph instruments were used, and the system was extended to several towns. In 1878 the discovery of the microphone made the telephone a practical instrument, and a company was started for acquiring and working Bell's patent. In 1879 that company sought an alliance with the Post Office, by which the Post Office would obtain telephones at cost price, and would in return facilitate the operations of the compay, although at that time there was no suggestion of an exchange system. Those negotiations came to nothing. In the same year the Edison Telephone Company was established, and in the autumn of the year announcements were made in the Press that telephone exchanges would be established, and that was the first suggestion of a telephone exchange in the country, although the first telephone exchange was established in Chicago in 1878. The Post Office immediately pointed out that the proposal would infringe their rights, and an information was filed against the company on November 27th, and also against the United Telephone Company. In June, 1880, these two companies amalgamated under the title of the United Telephone Company, Limited. On December 20th, 1880, judgment was given in the High Court of Justice in favour of the Post Office, and in anticipation of that judgment, the Post Office made arrangements to establish telephone exchanges of its own, and steps were taken to obtain a sufficient number of telephones to enable the Department to carry out the work. At the same time the Department entered into negotiations with the telephone companies to grant them

licenses, which were to be granted under the Telegraph Act of 1869. It was under that Act that all subsequent licenses were granted. In accepting the licenses the companies at the same time accepted the judgment of the High Court. There was a willingness on the part of the Government of the day to give the licenses, but it was not a bargain to prevent the companies appealing.

The Chairman: I suppose if the companies could have successfully carried on an appeal against the Post Office they would have done so.

Witness: I should think so.

Sir Julian Goldsmid: That is problematical.

The Chairman: It is human nature.

Witness said the Post Office had not the least doubt as to its rights, and he was decidedly of opinion that it was not through any fear that the Post Office granted the licenses. On judgment being given, the Post Office issued advertisements stating that the telephone system would be substituted for the "A B C" system, and offering to establish telephone exchanges wherever they were required. In April, 1881, the United Telephone Company was granted a license to carry on telephone exchange business in London, and the company accepted the judgment of the High Court. The radius within which they were to carry on their business was five miles from a central point selected by themselves; and, of course, royalty was to be paid to the Post Office. With regard to the provinces, the policy of the United Company was to confine its own exchange operations to London, and to allow its patent apparatus to be used in other parts of the country by subsidiary companies, and let them negotiate with the Post Office for licenses in provincial towns. The company had a practical monopoly of all the best telephonic apparatus. Licenses began to be granted in 1881. They were for 31 years, but were all dated for that year, and would expire in 1911. In 1881, the Post Office allowed the exchange companies to be connected with the Post Office, so that the companies' subscribers could send telegrams for transmission over the public wires; but that privilege was taken advantage of to only a limited extent, and, in the meantime, the Post Office established telephones itself in Cardiff, Newport, and other towns. The Post Office also offered to supply trunk wires on condition that the persons using them should pay to the Department direct; but that offer was not accepted, and in the few cases where wires were provided from one town to another for the companies, it was done at a fixed annual rent. The wire between Cardiff and Newport was now used by the Post Office. About 30 towns were supplied in this way by the Department. In the meantime, licenses were gradually being granted for other towns—generally to the subsidiary companies of the United Telephone Company. In 1882, a new company, called the Globe Telephone Company, appeared on the scene, and applied for license to carry on exchange business in London, and the United Telephone Company urged reasons why there should be no competition. The license, however, was granted, and in the same year licenses were granted for companies to carry on business in towns where up to that time the Post Office had retained the business in its own hands. In 1889, the Globe Telephone Company was absorbed by the United Company, and in the same year Mr. Grey accused the Government of pursuing a policy of strangulation with respect to the companies, and Mr. Fawcett admitted that some of the conditions checked the development of private enterprise. After a consultation with the companies in July, Mr. Fawcett sought the authority of the Treasury to abolish all restrictions of areas, and to throw the whole country open to the operations of the licensees. Mr. Fawcett's policy was evidently to encourage competition, for in a speech in the House he said if there was to be a monopoly in the telephone business, it had better be in the hands of the Government. In that new arrangement the royalty was to be maintained, and the operations of the companies were to be still limited to oral communications. The Treasury sanctioned the arrangement, and it was announced in the House of Commons on August 7th, 1884. As the result of that, the present existing licenses were given in substitution for the old licenses. The main difference between the Fawcett licenses and the old ones was that the former were for the whole country, and authorised the erection of trunk wires. Altogether 23 licenses were given. At present there were 13 licenses in existence, but, as a matter of fact, all the companies holding them had been absorbed either by the National Telephone Company or the New Telephone Company; whilst the former company held nearly all the shares in the latter company, which was undergoing the process of liquidation, and therefore, for all practical purposes, it might be assumed that there was only one telephone company in existence. During Mr. Raikes's administration under the late Government, public dissatisfaction was expressed at the service rendered by the companies, and there was alarm at the uncontrolled monopoly which was being granted, and the Government was also influenced to consider the desirability of fresh arrangements by the repeated demands of the companies for further powers, in order to meet public requirements, and they were also concerned at the effect of the competition on the telegraphic revenue. In the six years, 1886—91, the gross revenue of the companies rose from £261,000 to £465,000, while the telegraph revenue was going down. In 1889-90 there was a balance of revenue over expenditure in the telegraph business of the country of about £88,000. In the following year that decreased to £85,000, and in the next year to £68,000. In 1893 there was a deficiency of £90,000.

Replying to Sir J. Goldsmid, Witness said his own conviction was that a great deal of that was due to the competition of the telephone companies. As far as he knew, they only established telegraphic communication in unremunerative places in Ireland, where it was absolutely essential for administrative purposes.

Continuing, Witness said that in the years 1886 to 1891, while the business of the companies increased 77 per cent., the ordinary inland business of the Department increased only 44 per cent. The deficiency in the telegraph service of 1893-94 rose to £178,000, and it was estimated that in the year 1894-95, the deficiency would be £240,000. He contended that the telephonic competition accounted for a good deal of that. The royalty paid in 1894 was £70,900. In 1891 it was £46,500, and in 1886, £26,000. The late government did not see their way to purchase the company's undertaking at the end of the first period mentioned in the license, viz., 1890, and after a great deal of consideration, they adopted the policy set forth in the Treasury minute of 1892. Their intention was to facilitate the operations of the companies by conferring on them certain powers of constructing telegraphs enjoyed by the Postmaster-General; to give additional facilities to the public by a closer combination of the telephone systems with the postal and telegraph systems of the Post Office; and thirdly, to safeguard the interests of the telegraphs by acquiring and working the trunk lines connecting different towns, and also to extend the trunk wire system, so as to bring into communication distant places, and enable communication to be made between Great Britain and Ireland, as had already been done between England and France. The right of the Post Office to establish telephone communication was fully preserved. A Bill was introduced to authorise the necessary sum of money being expended to acquire the companies' trunk wires, and provide capital for building other wires, and after being referred to a Committee, that Bill became law in 1892 as the Telegraph Act. In reporting to the House, the Committee expressed the opinion that the responsibility for the details of the agreement must rest with the Government, and they made the reservation that the duration of the licenses should not be extended. After a great deal of negotiations, arrangements were made with the companies, and the heads of the agreement were signed on August 11th, 1892. Since that time the Department had been engaged in the erection of trunk wires, and had already expended £374,000. Connections had been completed between Plymouth, Bristol, and the ports in South Wales, with Birmingham, Leeds, and Newcastle-on-Tyne. It had also completed lines from Hull to Leeds, and from Leeds to Manchester and Liverpool; from London to Chelmsford, Colchester, and Ipswich; from London to Brighton; from London to Derby and Leicester; from Edinburgh and Glasgow to Belfast and Dublin. Lines connecting London with Bristol, Southampton and Portsmouth, were in hand, and a main line from London, through Nottingham, Sheffield and Leeds to Glasgow would, it was hoped, be completed next month.

By Sir James Ferguson: The direct communication between London and Glasgow, and consequently with towns in communication with Glasgow, was new.

Witness further stated that 50 lines of minor importance was in course of construction. Mr. Lamb next came to the new agreement, and taking it clause by clause, explained that on July 1st the company would hand over to the Postmaster-General its trunk wires, which would be valued by experts. The operations of the company would be limited to specified exchange areas. The companies would construct connecting wires between their exchanges and the Post Offices, so that their customers might be enabled to use the trunk wires, and for the working of those connecting wires the Postmaster-General would make no charge. Charges for this had been made in the past, and that companies would be relieved of an expenditure of £1,600 a year. The Postmaster would provide underground wires between exchanges situate in the same area, and would give permission to the companies to make agreements with the railway and canal companies, over whose property he had exclusive rights of way, for the construction by the companies of telephone wires, for which they would pay him merely a nominal rental of 1s. per mile instead of 20s., as was before provided. That concession would make a reduction in the payments of the companies to the Department of £2,400 per annum. The power of the Postmaster-General to supply telephone exchanges, or allow others to do so, was fully reserved. To sum the whole matter up, the result of the agreement would be that there would be a complete national system of telephonic communication throughout Great Britain and between Great Britain and Ireland, and there would be placed at the disposal of the public facilities not only for telephonic intercommunication, but for a combination of the telephone and the telegraphic and postal services of the State.

The Chairman: That is to say, the development of the town intercommunication will be in the hands of the Post Office, and the development of the local exchanges will be in the hands of the companies.

Witness: Yes.

The Chairman: The taking over of the trunk wires by the Government is a step in the direction of the acquisition of the telephones.

Witness: Yes; I think that is obvious.

The Chairman: I would like to know your opinion shortly upon the question of competition in the telephone system—the effect of competition.

Witness said he believed both reason and experience pointed to the necessity of one exchange system in one area. As a matter of fact, every competing company had been absorbed by some existing company, and it appeared to him obvious that if they looked for efficiency and economy, they must have one system in one area. If the users of the telephone were divided into two groups, the persons in one group could not communicate with those in the other unless they subscribed to both systems. The experience of foreign countries bore that out. There was no difference of opinion amongst experts that competing systems in one area resulted in inconvenience to the public and want of efficiency.

In reply to Mr. Tully, Witness said he attributed a substantial part of the decrease in telegraphic receipts to the competition of the telephone system.

Replying to Sir Julian Goldsmid, Witness said that it was true that extensions in the Telegraph Department were paid out of revenue, and that the companies provided for that by an issue of fresh capital. There had been an enormous increase in the telegraphic staff over 10 years ago, and of course that accounts for some of the

deficiency. He did not think the commercial depression would affect the telegraph more than the telephone. He did not admit that the increased royalty made up for the loss of telegraphic business.

Examined by Mr. Benn, Witness said that Mr. Fawcett's policy was one of free trade, but he would not express the opinion that the present policy of the Department was a reversal of that policy. The Treasury minute certainly reversed that policy, inasmuch as the companies would be limited to certain areas. He took it that competition was contemplated in the Treasury minute. It was true that the National Telephone Company and the New Company came to an understanding between themselves before signing the agreement. They were not granting new licenses, but they were dealing with people already having powers. He knew that the patents of the companies had run out, but he could not say they had nothing else, because they had their business. He knew that the New Company had succeeded at that time in obtaining many subscribers, but he was not aware that those subscribers were ever served. He also knew that the chairman of the New Company came to the conclusion that the charges were too low, and he intended to raise them. The charges in London for the exchange were three times those of Christiania, and in proportion to the population of the two towns, the users in the latter were more than in London. He was certain that the business in London could not be carried on at the same rate in London as in Stockholm. He did think the acquisition of the trunk wires was a step in the direction of the acquisition of the system by the Government. He believed the agreement benefited the companies, inasmuch as it gave their subscribers greater facilities, and relieved them of payments they had hitherto made, and they also obtained certain powers with regard to wayleave. On the other hand it took away their power to do the business of a trunk wire. According to his information the receipts of the company for the trunk wires for the year ending December 31st, 1894, were £76,000. The value they assigned the wires was £490,000. He could not say that it was the least profitable part of the business without an examination of the companies' books. He should think the trunk wires between such places as Liverpool and Manchester paid very well, and he would expect in other places they did not pay so well. He knew that it was difficult to get the companies to come to the agreement, and he was not prepared to say that the companies were glad to rid themselves of the trunk wires. There was some misapprehension as to the charges. The charge of the Post Office would be 3d. for any distance not exceeding 20 miles, 6d. for any distance not exceeding 40 miles, and 6d. for every additional 40 miles.

Examined by Sir Charles Cameron, Witness said the right of the Post Office to grant licenses to other persons under the agreement was fully preserved. The two companies saw that clearly, and came to an understanding, which, in his opinion, clearly tended to the centralisation of the business of the two companies in the hands of one. It was clear that the Post Office could grant new licenses without any breach of faith. Whilst Mr. Fawcett's policy could be described as one of free trade, it was really defeated by the action of the companies themselves, because the United Telephone Company agreed with the provincial telephone companies that each should work only a limited area. As regarded the wayleave, the companies would have to arrange with the railway and canal companies as to the rent they would pay; the 1s. per mile which the companies would pay the Post Office would only be in respect of the Postmaster-General's monopoly. He believed that there were a large number of persons who had private wires between their offices and residences, &c.

In reply to Sir Frank Lockwood, Witness pointed out that the cost of wayleave, &c., in London, was much higher than in Stockholm, whilst the facilities were greater.

The Chairman: Is it a fact that the telephone takes away the most remunerative part of the telegraphic business?

Witness: Yes, that is so; they get the short distances, and we get the messages which have to be taken across country.

Sir Robert Hunter, solicitor to the Post Office, was called, and replied to a few questions in explanation of certain sub-clauses in the agreement. The agreement gave full power to the Postmaster-General to grant licenses to municipalities, or for the Post Office itself to enter into competition.

The Committee then adjourned till the following Friday.

THE BEST COMBINATION OF PLANT, MAINS, &c., FOR AN ELECTRIC LIGHT UNDERTAKING.*

By R. A. DAWBARN, M.I.E.E.

The title given to this paper on the syllabus includes the word "ideal," but upon starting to draft it, I struck out that epithet lest it should mislead, as it has from the first been my intention to place before you the conclusions I have arrived at as to the best mechanical and electrical equipment for an electric light station under the normal conditions of an English provincial town, from purely practical considerations, which may, of course, require some modification to satisfy colonial or special conditions.

System.—In this year of grace, 1895, one is fortunately spared an exhaustive investigation into the question of system. The great duel—alternating *versus* direct currents—was fought to the bitter end, and one of them is dead, but in case any member of this society should still have his doubts on this point, an examination of the two comparative maintenance estimates placed before you will, I trust, satisfy him. These estimates were recently prepared in conjunction with a detailed tender on each system to demonstrate their relative merits to the electric light committee of a northern town of about 55,000 inhabitants, and in each case provide for a 24 hours service per day throughout the year.

SCHEME I.

High and Low Tension Alternating Current Transformer Systems.

Estimated Annual Cost of Maintenance for Private Lighting.

Assumptions.

Total capacity of running plant (excluding spare plant) ... ... 100,000 watts.

Load factor.—Assume 10 per cent., *i.e.*, the consumers' demand as represented by the units sold per annum is only estimated to reach 10 per cent. of that which the running plant could supply if kept fully loaded 24 hours per day throughout the year.

Units sold per annum.—(on the above basis) $= \frac{100{,}000 \times 365 \times 24 \times 10}{1{,}000 \times 100} =$ 87,600 B.O.T. units per annum.

Materials.	£	s.	d.	£	s.	d.
Fuel (coke breeze).—87,600 units, at 15 lbs. per unit = 586·6 tons, say 587 tons at 3s 6d.	102	14	6			
Water.—At 60 lbs. per unit = 525,600 gallons at 8d. per 1,000	17	11	0			
Oil, Waste, &c.—$\frac{1}{10}$d. per unit = $\frac{87{,}600}{10 \times 240}$	36	10	0			
				156	15	6
Wages.						
One engineer in charge	£200	0	0			
Three engine and dynamo men, 30s. ...	£4	10				
Three stokers, 25s.	3	15				
One reserve man	1	5				
52 weeks at £9 10 =	494	0	0			
Add for Sunday labour 10 per cent.... ...	49	0	0			
				743	0	0
Repairs.						
1 per cent. on buildings, say £1,500... ...	15	0	0			
2½ per cent. on generating plant, say £4,500	112	10	0			
1½ per cent. on transformers and mains, say £1,100	16	10	0			
				144	0	0
Interest and Sinking Fund.						
5 per cent. on £9,000				450	0	0
Additional office expenses and collection, &c.				150	0	0
Total expenditure ...				£1,643	15	6

Cost per B.O.T. unit = 4·502d.

SCHEME II.

Low Tension Continuous Current System.

Estimated Annual Cost of Maintenance for Private Lighting.

Assumptions.

Total capacity of running plant ... ... = 100,000 watts.

Load factor, as before, 10 per cent.

Board of Trade units sold per annum on the above basis ... ... = 87,600 B.O.T. units.

Of this amount the accumulators will approximately supply... ... ... } 13,150 B.T.O. units per annum.

The losses due to charging accumulators assumed to be outweighed by the higher average load during the day time.

Materials.	£	s.	d.	£	s.	d.
Fuel.—87,600 units at 14 lbs. per unit = 548 tons at 3s. 6d.	95	5	0			
Water.—At 60 lbs. per unit = 525,600 gallons at 8d. per 1,000	17	11	0			
Oil, Waste and sundries, $\frac{1}{10}$d. per unit ...	36	10	0			
				149	6	0
Wages.						
One engineer in charge	200	0	0			
Two engine and dynamo men, 30s. ...	£3	0				
Two stokers, 25s.	2	10				
One accumulator and reserve man, 30s.	1	10				
52 weeks at £7 0 =	364	0	0			
Add for Sunday labour 10 per cent.... ...	36	0	0			
				600	0	0

* A paper read before the Falcon Works Engineering Society, Loughborough, February 6th, 1895.

Repairs.

1 per cent. on building, £1,500	15 0 0		
2½ per cent. on generating plant, £4,600 ...	115 0 0		
Accumulators, 132 cells at 11s. 9d.	77 10 0		
1½ per cent. on mains, say £1,800	27 0 0		
		234 10	0

Interest and Sinking Fund.

5 per cent. on £10,500		525 0	0
Additional office expenses, collection, &c.		150 0	0
Total expenditure		£1,658 16	0

Cost per B.O.T. unit = 4·54d.

It will be observed that there is practically no difference in the total annual cost of the two systems, even under the conditions most favourable to an accumulator system, namely, when the station is as small as it would ever pay to work, notwithstanding that it has been assumed that the direct current scheme would be a little more economical of fuel, owing to the use of accumulators, which admit of the station being closed say 8 hours out of every 24, and that the upkeep of the accumulators would not cost more than the price at which the makers will undertake to keep them in repair for three years, representing about 7 per cent. of their first cost per annum—a figure which would doubtless be materially increased during a second period of three years, even if the makers have not hidden their own estimate of the cost of upkeep for the first three years by partially concealing it in the sale price of the cells, a contingency by no means improbable when it is remembered that no one—not directly interested in accumulators—ever finds their upkeep cost less than 12 per cent. per annum of their first cost.

The estimates, however, as they stand, may be taken as fairly representing the relative merits of the two schemes in their earliest stage of development, and we must ask ourselves what will be the effect of increased output and extended area of supply as time goes on?

Let us take the case of a low-tension feeder ¼-mile long, feeding the two "outers" of a three-wire system, and giving 200 volts at the feeding point. On the basis of 1,000 ampères per square inch, the drop of pressure in the cable would be 22½ volts, or, say, 10 per cent. of the initial pressure. Assume, now, that the extensions demand a second feeder ¼-mile long; in order to get the same drop in double the distance, the section of cable to carry the same current must be doubled—that is to say, the current density must be only 500 ampères per square inch, and double the length of cable having double the section means, approximately, four times the cost.

On the other hand, 22½ volts drop is but 1¼ per cent. of 2,000 volts, and if we adopt this same current density for a ¼-mile feeder on the high tension system as for a ¼-mile feeder on the low tension system, viz., 1,000 ampères per square inch, the drop will be only 2½ per cent., which no one will suggest is extravagant, and obviously does not demand a lower current density, or, in other words, a greater sectional area of copper. Consequently when we are called upon to extend, by putting down feeders double the length of those serving the first area and carrying the same current, we can do so on the high pressure system for double the cost of the first feeders, whilst on the low pressure system it would involve four times the cost of *its* first feeders to convey the same amount of energy.

Now, let us look at an actual case and see what the real difference in cost is in money:—

	£	s.	d.
Half mile of H. T. concentric armoured cable ·050 square inch section, carrying 50 ampères at 2,000 volts (= 100,000 watts) costs...	135	0	0
Half mile of L.T. concentric cable to carry 100,000 watts at 200 volts means 500 ampères, and at 500 ampères per square inch involves a section of 1·0 square inch, costing	1,110	0	0

Allowing 5 per cent. for interest and sinking fund and 1½ per cent. for repairs, this means an additional annual charge on the low-tension system of 6½ per cent. on the difference between these two capital sums, *i.e.*, 6½ per cent. on £975, or £63 7s. 6d. per annum.

The relative sections of copper in these two cables is as 1 to 20, and it must not be forgotten that the loss in the larger cable is 10 per cent. against 2½ per cent. in the smaller one for the same distance.

I may be reminded that in the above comparison no notice has been taken of transformers. In any case transformers to the capacity of 100 kw. (say four of 25 kw. each) would only account for £240 out of £975, but their cost is amply covered by the saving in low tension distributers, owing to the absence of the middle wire, and to the reduced section of conductor admissible as the result of employing a larger number of feeder points than it is practicable to adopt on the low tension system, because in the latter a separate pair of cables from the station is essential for every feeding point, whilst in the high tension system several transformers at different points can be fed off one pair of cables (or one concentric cable, which is the same thing), all at practically the same pressure.

I will ask you therefore to remember that the saving in capital outlay on a half mile feeder to carry 100 kw. on the 2,000 volt high tension system, as compared with that required on the low tension 200-volt 3-wire system, represents no less than £63 per annum, or practically equivalent to the saving that would result by dispensing with one of the stokers.

You will thus see that as the area of supply grows, the difference in the total annual costs of the two systems will become more and more marked, and show a correspondingly increasing advantage in favour of high tension.

Regulation.—In the matter of regulation it is common knowledge that a decidedly more uniform pressure at the lamps is invariably to be found in practice on the alternate-current system. This is readily understood when we remember that the pressure in the generating station, according to whether the mains are lightly or heavily loaded, would never require to be varied more than 3 or 4 per cent. in a high tension system, whilst from 15 to 20 per cent. variation with a low tension system for the same area of supply would be inevitable. Bearing upon this subject, the following extract from the *Electrical World* of New York, dated June 7th, 1894, is of interest:—

"Mr. Claude in discussing the disadvantages inherent in the three-wire system, concludes that in any case the regulation for constant voltage cannot be accomplished as perfectly as in the simple system. He shows that in case the drop in volts in the neutral wire for the extreme lamp is greater than the loss in one of the outside wires, the apparently paradoxical result may be that the voltage is higher at the extremity of the line than at its origin."

It may interest you to know that a case came under my notice about 18 months ago, in which precisely the conditions here referred to were actually obtained in practice in the early days of an undertaking.

Another great advantage of the alternate current system is that it is much more elastic, and the service mains can be arranged to accommodate themselves to unforeseen demands in a manner quite impracticable with a direct current system. We will recur to this subject later. Then again, service joints can be kept smaller and of one standard size on an alternate current low tension network.

Load Diagram.—In considering any particular case, one has first to satisfy oneself as to the capacity of plant that may fairly be expected to be loaded during the first year or so of running. The next point to be determined is the number and size of units to be employed, and to do this effectively one must have a sufficient knowledge of electric light load diagrams for various classes of lighting to be able to predict with tolerable accuracy the probable load diagram for the town under consideration. From careful observations I have made, the following data may be considered as applying generally for mixed lighting within fairly close limits:—

(*a*) An average "load factor" is 10 per cent.; that is to say, the undertakers may expect to sell in a year 10 per cent. of the units which the "*running plant*" (neglecting spare) could generate in one year, working at full load continuously night and day, assuming that the maximum load on a winter evening just reaches the full capacity of the running plant. Or, to express it in figures: A plant of 100 kilowatts capacity, which working night and day on full load throughout a year of 8,760 hours could generate 876,000 B.O.T. units, would in practice only be called upon to supply 87,600 units with a top load of 100 kw, beyond which we must have spare plant equal in capacity to the largest unit employed.

(*b*) Given the units sold in December, one may anticipate that the units sold per annum will amount to about 60 per cent. of the December units multiplied by 12—the number of months in a year.

(*c*) The units sold on the lightest summer day represent only about one-sixth (16·6 per cent.) of the units sold on an average December day.

(*d*) The maximum current demanded in June or July is only between one-fourth and one-fifth (20 per cent. to 25 per cent.) of the maximum current in December.

(*e*) The minimum current occurs between 4 and 5 a.m., and on direct current stations may be only one-fiftieth, or 2 per cent., of the maximum winter load. On alternate current stations this would not fall below 4 per cent., and where separate house transformers are used, might be as high as 6 per cent. or 7 per cent.

(*f*) The midday current on a fine winter day is less than one-seventh (say 14 per cent.) of the maximum evening current.

Generating Units.—From the above it follows that the day load unit should have a capacity not less than 14 per cent. of the total running plant capacity, and to allow for extensions, say, 20 per cent. to 25 per cent.

Referring to the maintenance estimates on the wall, the plant there provided comprised two 75-kw. sets, and one 25-kw. One of the larger sets is treated as spare, consequently the "running plant" is represented by one 75-kw. and one 25-kw. set, or 100 kw. in all. The capacity of the day load set is thus 25 per cent. of the running plant, but as soon as another 75-kw. set is put down, it becomes only 14·3 per cent. of the running plant capacity.

As regards the number of generating units to be employed, one must be guided by several considerations. It is now well understood that in order to keep down the fuel consumption, the capacity of the plant running must be very little in excess of the demands of the moment, and as a result there are several stations at work which started with half-a-dozen units all of one size; but I am strongly of opinion that it is not wise to start with so many units, notwithstanding that for the time being the fuel consumption may suffer.

To illustrate my point, I must again refer you to the maintenance estimates, from which you will see that the cost of fuel is a much less important item than labour. In the particular case before you, the cost of fuel is exceptionally low, as it is proposed to place the station at the Corporation gas works, and supply the boilers with small coke breeze; but suppose we assume coal at 10s. per ton, this would add £190 16s., and make the total cost of fuel £293 10s. (or ·804d. per unit), but the cost of labour and supervision is £743 (or 2·03d. per unit).

Now it is obvious that you would require more attendance on six steam sets than on three to give the same output, and if of the same type, the six sets would cost more to keep in the repair than the three. It must also be borne in mind that the station is bound to grow, and in the course of 10 years or so the six small sets would be mere toys compared with the extension units.

I would also remind you that by adopting the larger units the capital outlay is reduced, as the larger units are cheaper per kilowatt of output. The effect of capital outlay on the total cost per unit sold has apparently been lost sight of altogether in the earlier stations, and is still ignored by the majority of consulting engineers. In the

case before you, the item "interest and sinking fund" is £450, or 1·23d. per unit; more than 25 per cent. of the total cost; and whilst the costs per unit of both material and labour are bound to be reduced as the result of increased output and greater efficiency of staff, the item of interest on capital, on the contrary, when once expended, is irredeemable. It behoves us, therefore, to give the greatest consideration to first cost.

I have suggested three units wherewith to start the minimum station, but *not all of one size*, for, as already shown, the smallest unit should not exceed 25 per cent. of the "running plant" capacity, and, preferably, represents about 14 per cent.

In the station before you, comprising one 25 kw. and one 75 kw. set as running plant, and another 75 kw. set as spare, it is presumed that in the course of a year or so, at most, another 75 kw. running set will be required, when very fair fuel economy will be attainable and *better* all-round results—fuel, labour, repairs of plant, and interest on capital included—than would be the case with half-a-dozen small units of the same aggregate running capacity.

Type of Plant.

Boilers.—On the question of boilers it is not my intention to give more than a few words in passing. In large cities subject to sudden fogs it is essential to be able to raise steam quickly, and consequently some form of water tube boiler with large heating surface, large grate area, and relatively small water capacity should be employed, but in smaller provincial installations the "Lancashire" type is to be preferred for the very qualities that make it unsuitable for large cities. Its large water capacity relative to heating surface renders its water level and steam pressure much more stable, and it consequently requires much less attention on the part of the stoker, whilst the fact that in the smaller stations a single boiler will supply the full running plant renders the feature, that it is not a quick steamer, inapplicable. As the station grows, it may be advisable to extend with water tube boilers, but I attach importance to the use of "Lancashire" boilers for day load and late night use (say after midnight) because a stoker can with a large "Lancashire" lightly loaded easily spare sufficient time to attend to the mechanical (as opposed to electrical) requirements of engine and dynamo, such as oiling, looking out for hot bearings, &c. As to the type of boiler suitable for extension, I venture to think that the "Stirling," which is well known in America, has features which cannot fail to command the attention of electrical engineers before long. A sketch of this boiler is on the table.*

The construction is briefly as follows:—There are four drums employed, including the mud-drum, from which latter tubes radiate to the three steam drums above, the steam spaces of which are connected by other tubes, but the steam drum furthest removed from the furnace and into which the feed-water is delivered, has no connection below water line with the other two steam drums except through the mud-drum. The most approved feed-water heater principle is thus applied to the boiler itself so as to cause the feed-water, whilst slowly passing towards the hotter gases down the nearly vertical tubes to the mud-drum, to deposit therein practically the whole of the solid matter in suspension before rising again to the more active tubes. It is claimed, as a result of this construction, that the tubes are much freer from deposit than those of other water-tube boilers.

Direct Coupling.—Notwithstanding that direct coupled plant is a trifle more expensive than rope driven, the difference is much more than covered by the saving in ground space, buildings, rope renewals, and fuel consumption due to the higher efficiency of direct coupled plant. This last item is of more importance than usually supposed, because the losses due to rope driving, which may be taken as 6 per cent. on full load, are practically constant for all loads, and since an electric light plant is not usually more than about half loaded on the average, this means fully 10 per cent. of the fuel bill saved by direct coupling alone, provided the dynamo is not run so slowly as to be materially less efficient. The Brush Company's list price for a 100-kw. rope set is £1,530, and of a direct coupled set, with the same type of engine, is about £220 higher. Taking the fuel bill for each 100-kw. of running plant as £293 10s. per annum, if we can save 10 per cent. of that amount per annum by spending only £220 more in the first instance—not to mention the saving of rope renewals, &c.—we can have no difficulty in making up our minds once for all in favour of direct coupling; at any rate, in fairly large sizes.

(To be continued.)

* This will appear in our columns later.—Eds. Elec. Rev.

THE McPHAIL AND SIMPSON SUPERHEATER.

If we are to believe the modern theory of the behaviour of steam in the cylinder of an engine, and of the various interactions between the steam and the cylinder metal, and it is difficult to find any consistent series of arguments against such theory, then we are perforce driven to put faith in superheating as the system, *par excellence*, for combatting the evils which arise from such actions as are assumed to exist. Prof. Unwin recently pointed out how singularly clear were some of the steam engineers of John Penn's time—including Penn himself—upon this subject of superheating, and he appeared to attribute the disuse of the system very greatly to the newer men, who, with ability as mere mechanics to produce excellent engines as going machines, were yet profoundly in the dark so far as regards the nicer questions of engineering, such as involve some knowledge of physics. Such men made engines to sell them; their engines turned round and ground out a proper amount of power, but, that a hot cylinder could condense the initial steam, that a rough piston could make an engine wasteful, or that there could be anything in existence not grossly palpable to their own coarse fibred minds never suggested itself to them, and when cylinders rotted and became soft, and pistons corroded into holes, and cast-iron could be cut like putty, it was all set down to the sinfulness of high-pressure steam by the men who wanted to carry on a bit longer the making of punched pot-metal boilers. Mineral oil came along and it is now known that all the old trouble was with tallow, and before long superheating is likely to receive a great impetus. Within the last two or three years Messrs. McPhail and Simpson, of Wakefield, have made a superheater, or steam dryer, with which very good results have been secured, and a saving as much as 30 per cent. has been effected on special tests, and, in one case, of nearly 50 per cent. in fuel, an evaporation of 10·9 pounds being secured as against 7·27 pounds from and at 212°. It will be observed, and this applies to each of six comparative tests made, that the evaporation without the superheater was poor, and there was room for improvement in these tests made by Mr. Waugh, of the Yorkshire Boiler Insurance Company. The same boiler that thus showed nearly 50 per cent. improvement was also tested within a day or two of each of Mr. Waugh's tests by the Manchester Steam Users' Association, and an economy of 31·1 per cent. appeared; but they also tested the engine of about 250-H.P. made by Pollitt and Wigzell, and found that, while with ordinary steam it consumed 18·9 pounds of water per H.P. hour, the consumption with the superheater was 18·35 pounds, a result as surprising as unexpected and quite opposed to all present day ideas on the subject of the economy due to superheating.

Another test by the Manchester Association at another place showed an increased evaporation from 10·02 to 13·77 pounds, and, on a confirmatory test, of 12·88 pounds, but unfortunately no comparative engine test was made. Other tests made at other places by other men showed savings of 30 per cent. or more, and one firm write to say they have had no trouble in the matter of lubrication since putting in the superheater, though they admit using a superior oil. Again, Mr. Crosland, of the Boiler Insurance and Steam Power Company, made tests of the same boiler tested by the two previously named companies, and showed an economy of 31·5 per cent. from the use of the superheater, so far as regards the boiler, but in the engine the steam consumption was 18·91 pounds without, and 18·76 pounds with the superheater. In this case, however, the testing engineer points out that only 9° of superheat were added, and all this was lost before the steam reached the engine, which should be sufficient to account for so little difference in the water consumption of the engine. The Manchester Association took no steam temperatures, their results may thus be put aside as regards the engine. As, in Mr. Crosland's tests, the steam was wet when it entered the engine on both occasions, it is possible, if there was a separator in use, that the engine was supplied with an equal quality of steam on both tests. The economy in the coal used was thus nearly all a matter of increased evaporation, and but very slightly due to any improvement in the cylinder action.

The usual arrangement of this superheater is as follows:—steam is taken from the usual anti-priming pipe into a range of small steel tubes placed, in the case of a Lancashire boiler, at one side of the downtake; thence it is carried in pipes along the boiler bottom internally, giving up heat to the surrounding water, and, doubtless, much facilitating and increasing the circulation. This done, the steam passes through another set of small tubes on the other side of the downtake, and then again through the water space in the boiler—this time above the furnace tubes, and it is again deprived of at least the greater portion of its acquired superheat—indeed it is a question to us whether this last passage in the boiler is not likely to be carried to too great an extent and the steam brought back to saturation temperature, as was almost done in the case above referred to. The net result as regards the boiler is, however, so far as can be learned—and we have direct testimony from Mr. Patchell, of the Charing Cross and Strand Electric Light Company, to the fact—a very substantial improvement in evaporative efficiency. It has always been accepted as a fact that heat travels by virtue of difference of temperature, by, in fact, what is termed its head of temperature, but there would almost appear to be good reasons to infer from various practical facts connected with feed heating and the use of live steam to effect this, and the economy consequent upon what seems very like paying from one pocket to the other, that heat transference will take place better from hot gases to comparatively hot metal than from hot gases to very cold metal. Probably experiments are lacking to prove whether there be any foundation for this supposition, but if the stoking of the fires in the tests of the McPhail superheater was—and we have no grounds to suppose it was not—honest, the very great additional evaporation would seem to be out of proportion to the additional surface provided by the superheater tubes, this surface being a little over 50 per cent. additional. But an addition to the ordinary heating surface of one-half would not produce anything like so great an effect, and we are almost compelled to suppose that it is to the manner in which this additional surface is employed that the results obtained are due; at the same time, while suggesting this, it must not be overlooked that the superheater is placed in a very favourable position for acquiring heat, the whole of its several hundred feet of surface being placed in the hottest place in the flues, beyond the furnace tube in Lancashire boilers and just past the first water-tube section in water-tube boilers, and is, therefore, in a position to act to best effect. Mr. Crosland points out that one tested boiler of Lancashire type 30 feet by 8 feet produced 10,910 lbs. of steam per hour, burning 24·46 lbs. of coal per square foot, or an equivalent of 840 I.H.P., with a triple expansion engine using 13 lbs. of steam per horse-power hour! So far as yet tried, the superheater appears to be durable. It is natural that an engineer should ask as to the behaviour of any foreign matter carried over with the steam, and it would be satisfactory to learn, also, what effect could be obtained in the engine economy if a really definite and substantial amount of superheat were maintained in the working steam. The tests cited have no value in this respect, though valuable as to the boiler, to which alone they were specially intended to apply, but engineers want to know more of the practical effects of dried and superheated steam upon their engine economies, for, at present, they naturally incline

to believe that, by means of superheat, they can work an engine over a wider range of power, without so greatly reducing its efficiencies at early points of cut-off—a point specially important in electric work, both lighting and traction. In our leader of March 22nd we referred to the possibility of incrustation, and it is satisfactory to find that Mr. Patchell, whose experience extends over twelve months, finds that the first tube box of the superheater acts as a very efficient separator of water, and collects the mud and salts that come over in the priming, and these are regularly blown out and the tubes do not scale. Such being the case, there appears no reason to fear specially severe wear of the tubes, and a really valuable adjunct has been provided to steam boilers. At the same time it should not be expected in daily practice to obtain economies in boiler efficiency of 30 per cent. or more, such as may have been secured on test occasions with boilers that were not, to begin with, giving much evaporation. There are two principal reasons for a poor boiler efficiency, the one due to the use of too much air in the furnace, whereby everything is cooled down; the other is excessive scale. With the former the addition of a superheater will not prove so great an economy as the latter, for the gases are all cold, whereas when the second cause is the reason of poor efficiency and the stoker is not to blame, the gases pass away at an excessive temperature and a superheater will show remarkable returns.

Seeing how important it is that there should be a definite amount of superheat conveyed to the engine, and that with the McPhail system there may actually be none, it may perhaps not be out of place to suggest that there should be a bye pass whereby some of the highly superheated steam may be taken direct to the steam main without passing through the final water-enveloped coil in the boiler. This could easily be effected; it would ensure that some superheat was always present in the engine, and yet over dryness would be avoided, and indeed the temperature of the steam passing to the engine might be made to automatically regulate itself within a small range. "Combined steam" is not novel; Rankine credits the idea to the Hon. John Wethered, and this new superheater seems to be very suitable for carrying the idea into practice. Properly speaking, a superheater ought to diminish the water consumption of an engine some 15 or 20 per cent., and probably do as much to increase the efficiency of an already well stoked and clean boiler. Practical men with boilers to force in face of an unfortunate aptitude to prime, will however, give as great a welcome to a superheater, which makes almost a virtue of priming, as to any economy effected, and there is no doubt that the small tubes of a superheater will effectually deal with priming even when quite heavy, and that the danger to engines will be minimised where superheaters are used. At the same time we are strongly of opinion that in asking £416,000 for the business and patents, a very extravagant demand is being made on the public. There are other ways of superheating and the figure asked is altogether too much.

NEW PATENTS—1895.

5,069. "Method of and apparatus for regulating circuits." J. M. Bradford. Dated March 11th.

5,086. "Improved means for connecting the branch wires of an electric lamp to the main conductors or for other similar purposes." H. S. Cowx. Dated March 11th.

5,093. "An improved electric gas-lighter." F. M. Kass. Dated March 11th. (*Complete.*)

5,102. "Improvements in electric arc lamps for optical lanterns, projectors, and the like." A. Barrett. Dated March 11th.

5,131. "Improvements in and relating to telephone apparatus." W. B. Robeson. Dated March 11th.

5,137. "Improvements in the construction and working of electrical transformers." S. Z. de Ferranti. Dated March 11th.

5,189. "Improvements in telephonic communication." T. Tomlinson. Dated March 12th.

5,196. "Improvements in thermo-electric generators." H. B. Cox. Dated March 12th. (*Complete.*)

5,199. "Improvements in telephone transmitters and in telephone receivers." C. Jackson. Dated March 12th.

5,205. "Process for the production of electrode plates for electric collectors." C. Luckow. Dated March 12th. (*Complete.*)

5,231. "Improvements in or relating to the automatic regulation of the current carrying capacity of fuses for electric currents." F. G. Baily. Dated March 12th.

5,236. "Improvements in apparatus for starting electric motors." H. W. Ravenshaw and Easton, Anderson, & Goolden, Limited. Dated March 12th.

5,269. "Improvements in mechanism for forming battery plates." C. J. Reed. Dated March 12th. [Date applied for under Patents, &c., Act 1883, Sec. 103, September 12th, 1894, being date of application in United States.] (*Complete.*)

5,309. "Electric alarm for clocks." W. Taylor. Dated March 13th.

5,311. "Improvements in incandescence lamps." A. R. Upward. Dated March 13th.

5,313. "Improvements in ohmmeters and other electrical measuring instruments." C. W. S. Crawley and A. Soames. Dated March 13th. (*Complete.*)

5,326. "An electrical safety stop for hydraulic motors." W. Carter and The Hydraulic Engineering Company, Limited. Dated March 13th. (*Complete.*)

5,331. "Improvements in recording wattmeters." J. Devonshire. (Communicated by W. C. Fish, United States.) Dated March 13th. (*Complete.*)

5,336. "Improvements in armatures of dynamo-electric machines." A. B. Blackburn and T. L. Boyden. Dated March 13th.

5,377. "Improvements in kinetoscope films." A. Lomax. Dated March 14th.

5,385. "Improvements in telephony and telephonic apparatus.' M. Kotyra. Dated March 14th.

5,392. "Improvements in treating metallic tape used in the manufacture of submarine electric telegraph cables and for other purposes." The Birmingham Small-arms & Metal Company, Limited, and W. H. Greenwood. Dated March 14th.

5,410. "Improvements in or relating to the means of protecting electrical conductors, water pipes, and the like." J. A. Kingdon. Dated March 14th.

5,428. "Electric transmitting thermometer." F. N. Denison. Dated March 14th. (*Complete.*)

5,451. "Improvements in self-recording electric meters." A. Wright. Dated March 15th.

5,500. "Improvement in incandescent lamps, having for its object to increase their illuminating power." A. Lucchesini. Dated March 15th. (*Complete.*)

5,515. "Improvements in electric measuring instruments." R. E. B. Crompton. Dated March 15th.

5,521. "Improvements in electric couplings." O. March. Dated March 15th.

5,568. "Improvements in alternating current arc lamps." W. P. Thompson. (Communicated by W. Mathiesen, Germany.) Dated March 16th. (*Complete.*)

5,596. "Improved construction and arrangement of commutators for dynamos." S. Jevons. Dated March 16th.

5,601. "Improvements in signalling and electric search light apparatus." S. O. Cowper-Coles and L. W. N. Hickley. Dated March 16th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1894.

3,674. "Improvements in primary galvanic batteries and in the liquids used therein." W. H. Longsdorf. (Communicated by G. Hewett, of New York.) Dated February 20th. According to this invention the carbon element is placed within the porous cell, and is formed of a carbon plate, or preferably of a series of flat carbon plates, four or five is a convenient number, but there may be more or less, placed very near each other, but separated just sufficiently to allow free access of the depolarising fluid between them. These plates are secured together by means of aluminium fittings. The outer vessel (containing the zinc element) is charged with a solution of common salt (chloride of sodium), with or without sulphuric acid, and to which a small quantity of bisulphate of mercury is added, and within the porous cell is a saturated, or nearly saturated solution of crude nitrate of soda, to which is added an equal volume of commercial sulphuric acid of, say, 66° Baume, and, after cooling, seven parts of water. 3 claims.

5,253. "Improvements in or relating to apparatus for the production of electricity, and its utilisation for lighting, ventilating, and other purposes." W. L. Wise. (A communication from abroad by I. N. Lewis, of New York.) Dated March 13th. Consists chiefly in the combination of two magnetic switches differently adjusted for controlling respectively the connection of the machine and battery, and the connection of the poles of the armature with the external circuit on reversal of driving, said switches being adjusted to respond or operate at different potentials or voltages of the armature. 10 claims.

5,254. "Improvements in or relating to apparatus for the production of electricity, and its utilisation for lighting, ventilating, and other purposes." W. L. Wise. (A communication from abroad by I. N. Lewis, of New York.) Dated March 13th. Relates to apparatus in which a storage battery is employed, and is charged by a dynamo driven at a variable speed as, for instance, from a car axle or from a windmill. 3 claims.

6,482. "Improvements in or relating to multiple telephonic systems and apparatus." P. Moreau and J. Munier. Dated March 31st. Consists in the substitution in place of the method of working called "single" (that is to say, communication between two stations by manual transmission, at a speed variable but relatively limited), of a method of "time division," wherein several operators, at one and the same station may in succession and during equal periods of time, transmit a signal, or the constituent elements of a signal or message to another station with which the first is in communication, by the aid of an apparatus which establishes synchronous connection between the line at each end, and the instruments of the same order, viz., collector at the point of dispatch, and separator at the point of arrival. 8 claims.

8,599. "Improvements in electric arc lamps or lighting apparatus." J. B. McKeown. Dated May 1st. Relates especially to the mechanism for feeding and controlling the carbon rod, and has for its object to provide a simple and efficient method of construction. 3 claims.